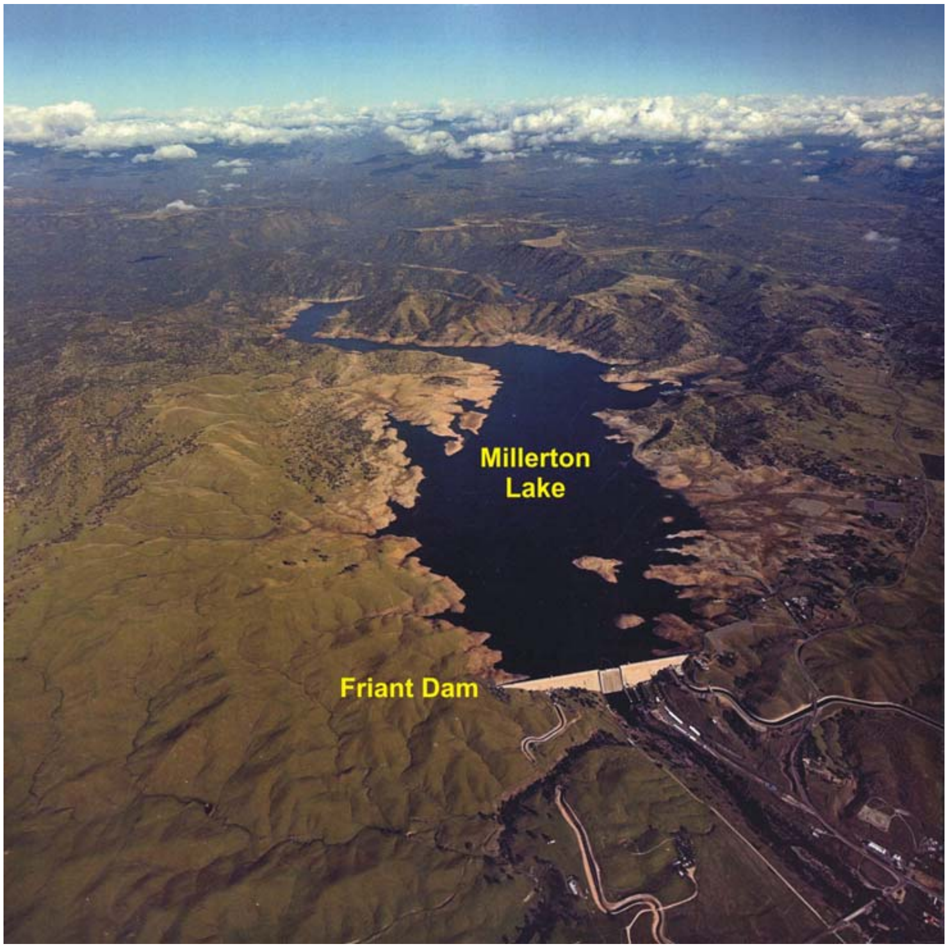

Draft Phase 1 Investigation Report

Initial Surface Storage Options Screening

Prepared for

U.S. Bureau of Reclamation

Mid Pacific Region

By

MWH
MONTGOMERY WATSON HARZA

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UPPER SAN JOAQUIN RIVER BASIN STORAGE INVESTIGATION

Draft Phase 1 Investigation Report In-Progress Review
Initial Surface Storage Options Screening

D R A F T

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LIST OF PREPARERS

NAME	ROLE
U.S. Bureau of Reclamation	
Jason Phillips	Project Manager
Chuck Howard	Lead Engineer
Joel Sturm	Geologist
Clarence Duster	Civil Engineer
Mark Pabst	Civil Engineer
Steve Higinbotham	Civil Engineer
Claire Hsu	CALSIM Modeling
Marian Echeverria	Public Involvement
California Department of Water Resources	
Waiman Yip	Project Manager
Richard Hayes	Civil Engineer, Hydrologist
Jeremiah McNeil	Engineer
Nate Wales	Engineer
Montgomery Watson Harza	
William Swanson	Project Manager
Stephen Osgood	Planner
Yung-Hsin Sun	CALSIM Modeling
Anna Fock	CALSIM Modeling
David Rogers	Engineering Team Leader
James Herbert	Engineering Geologist
William Moler	Engineering Geologist
Irina Torrey	Environmental Team Leader
Sara Hamm	Environmental Coordination
Philip Unger	Aquatic Biology
David Stevens	Wildlife Biology
Stephanie Murphy	Wildlife Biology
Sandra Perry	Recreational Resources
Barry Anderson	Botany
David White	Cultural Resources
James Darke	GIS Analyst
Steve Irving	GIS Technician
Colleen Montgomery-Lagousis	Document Production
CDM	
Coral Cavanagh	Public Involvement
Carrie Metzger	Public Involvement
Public Affairs Management	
Charles Gardiner	Public Involvement
MBK Engineers	
Walter Bourez	CALSIM Model Development
Dan Steiner - Consultant	CALSIM Model Development

CHAPTER 1. INTRODUCTION

BACKGROUND

Reliable high-quality water supplies are critical to maintaining California's economic vitality and the quality of life of Californians. Hydrologic conditions in the state range widely – both geographically and from year to year – and environmental demands on existing water supplies have risen in recent years. As a result, the availability and reliability of California's water supply are highly variable, a condition that will likely worsen in the future. The need for innovative water management strategies has never been more urgent.

In recognition of these needs, a consortium of State and Federal resources management agencies collaboratively developed the CALFED Bay-Delta Program to address the imbalance between water supplies and demands and provide for ecosystem restoration and protection. The principal objectives of the CALFED Program are to develop a comprehensive, long-term strategy to provide reliable water supplies to our cities, agriculture, and the environment while restoring the overall health of the San Francisco Bay-Delta Estuary. The CALFED Programmatic Record of Decision (ROD) of August 28, 2000 recommended numerous projects and actions to increase water supply reliability, improve ecosystem health, increase water quality, and improve delta levee stability.

CALFED Guidance for Storage in the Upper San Joaquin River Basin

The ROD describes an approach for reducing the imbalance between water supplies and demands in areas served by water projects that affect the Delta. A series of twelve programs were defined that, in combination, would help attain the overall goals of the CALFED program. One of the programs, water storage, includes five investigations of potential increased surface storage capabilities at various locations in the Central Valley including the Upper San Joaquin River Basin, and groundwater storage through conjunctive management. For the Upper San Joaquin River Basin, the ROD states:

> *"250-700 [thousand acre-feet (TAF)] of additional storage in the upper San Joaquin watershed… would be designed to contribute to restoration of and improve water quality for the San Joaquin River and facilitate conjunctive water management and water exchanges that improve the quality of water deliveries to urban communities. Additional storage could come from enlargement of Millerton Lake at Friant Dam or a functionally equivalent storage program in the region."*

The ROD plan for action includes the investigation of new surface water storage in the upper San Joaquin River watershed and completion of environmental and planning documentation by mid 2006. Consistent with this direction, the U.S. Bureau of Reclamation, Mid-Pacific Region (Reclamation) and the California Department of Water Resources (DWR) will complete the Upper San Joaquin River Basin Storage Investigation (Investigation). The ROD recommends an enlargement of Millerton Lake ranging from 250 TAF to 700 TAF or the development of a functionally equivalent storage program in the region. The Investigation will evaluate the range of potential accomplishments that would be provided from an enlarged Millerton Lake and will consider options that could be included in a regional storage program to provide functionally equivalent accomplishments.

STUDY AUTHORIZATION

Federal Authorization

The Investigation will address potential modifications or additions to the Central Valley Project (CVP), a Federal water resources project that was authorized in accordance with the Reclamation Act. Authorization for participation in this Investigation by Reclamation derives from the Reclamation Act of 1902, which authorizes the Secretary of the Interior to conduct appraisals of potential water resource opportunities.

State of California Authorization

Section 227 of the State of California Water Code provides authorization for DWR to participate in water resources investigations, as follows:

> *"The department may investigate any natural situation available for reservoirs or reservoir systems for gathering and distributing flood or other water not under beneficial use in any stream, stream system, lake, or other body of water. The department may ascertain the feasibility of projects for such reservoirs or reservoir systems, the supply of water that may thereby be made available, and the extent and character of the areas that may be thereby irrigated. The department may estimate the cost of such projects."*

PURPOSE AND SCOPE OF REPORT

The Investigation will consist of two phases. Phase 1 will be an appraisal level evaluation that will allow Reclamation to determine if a potentially viable plan appears likely, in which case, a Notice of Intent and Notice of Preparation (NOI/NOP) will be filed to formally initiate environmental review. Phase 2 will include detailed evaluation of project alternatives, preparation of an Environmental Impact Statement (EIS) and an Environmental Impact Report (EIR), and development of a ROD.

The Phase 1 Investigation Report will provide sufficient information to support decisions regarding initiation of Phase 2 studies. This report is an in-progress review document of the Phase 1 Investigation Report through the initial screening of potential surface storage options. Subsequent documents of the Phase 1 Investigation Report will include model simulation results, estimated project costs, and a description of potential benefits.

This in-progress review document is organized as follows:

Chapter 1 provides background on the Investigation.

Chapter 2 describes existing and future without-project conditions.

Chapter 3 identifies problems and opportunities that development of new water storage in the Upper San Joaquin River Basin could address.

Chapter 4 describes the plan formulation approach.

Chapter 5 describes surface storage options considered and initial screening results .

Chapter 6 describes next steps in the Phase 1 Investigation.

STUDY AREA

The Upper San Joaquin River Basin includes the San Joaquin River and tributaries upstream of its confluence with the Merced River. The study area for the Investigation includes the Eastern portion of the San Joaquin Valley, from the Merced River into the southern limit of the Valley. This area includes the region served by the Friant Division of the CVP and the portion of the San Joaquin River most directly affected by the operation of the Friant Dam. Figure 1-1 shows the locations of major water resources facilities in the San Joaquin Valley.

The area of potential impact from the development of new storage in the Upper San Joaquin River Basin includes the San Joaquin River downstream of Friant Dam, lands with San Joaquin River water rights, the Friant Division service area, and the eastern San Joaquin Valley groundwater basins. These areas comprise the San Joaquin River and the Tulare Lake Regions described in the CALFED ROD and shown in Figure 1-1.

RELATED STUDIES, PROJECTS AND PROGRAMS

This Investigation is proceeding at a time when several studies and related programs are considering water resources problems, needs, and opportunities in the San Joaquin Valley. Many projects are being coordinated through CALFED and member agency management. Some assumptions needed for conducting the Investigation apply to other CALFED storage investigations. The Investigation is being coordinated with other on-going CALFED storage and conjunctive management studies, as well as with other related projects and programs.

One major study under way in the San Joaquin River Basin is the development of a restoration plan for the San Joaquin River below Friant Dam by the Friant Water Users Authority (FWUA) and the Natural Resources Defense Council (NRDC). As part of this work, the FWUA and NRDC have been considering water supply options that could be developed to provide water for restoration needs. Information developed by that effort that is relevant and applicable to the Investigation is being incorporated to the extent possible.

Coordination with other projects and programs will be paramount to assure consistency in relevant assumptions, identify project opportunities, and reduce the potential for duplicate efforts. Other studies and on-going programs in the San Joaquin Valley that are, or may be, addressing some of the issues being considered in this Investigation include:

CVP Yield Replacement Plan (CVPIA Section 3408(j))

Westside Integrated Resources Plan

San Joaquin River Management Program

San Joaquin River Riparian Habitat Restoration Program

San Joaquin Basin Action Plan and Grasslands Wildlife Management Area

San Joaquin River Parkway and Conservation Trust

San Joaquin River Conservancy

Central Valley Habitat Joint Venture

Vernalis Adaptive Management Plan (VAMP)

Sacramento-San Joaquin River Basins Comprehensive Study

Reclamation's San Joaquin Valley Drainage Program

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FIGURE 1-1. SAN JOAQUIN VALLEY

CHAPTER 2. EXISTING AND FUTURE CONDITIONS

EXISTING CONDITIONS

This chapter presents a general description of existing water resources facilities and conditions in the study area, and describes how they are expected to change in the foreseeable future. It is included to provide an understanding of existing water management operations that could be affected by the development of additional water supplies in the Upper San Joaquin River Basin.

The San Joaquin Valley is approximately 250 miles long, 30 to 60 miles across, and is bounded on the north by the Sacramento-San Joaquin Delta, on the south by the Tehachapi Mountains, on the east by the Sierra Nevada foothills, and on the west by the Coast Range (Figure 2-1). Irrigated agriculture has been the mainstay of the San Joaquin Valley economy since the first water diversions for irrigation began in the 1860s. Since that time, agriculture has developed to become a major economic contribution to both the State of California and the Nation. Three of the counties in the study area – Fresno, Kern, and Tulare – consistently rank among the Nation's top four counties in agricultural revenue. Exports of cotton, citrus, and produce also contribute substantially to the international market.

Hydrology

The San Joaquin River originates in the Sierra Nevada at an elevation over 10,000 feet and enters the San Joaquin Valley near Friant. Below Friant Dam, the river flows west to the center of the Valley, then turns sharply north at Mendota Pool and flows through the San Joaquin Valley to the Delta. Along the Valley floor, the San Joaquin River receives flow from the Merced, Tuolumne, and Stanislaus rivers as well as from smaller tributaries from the east and west sides of the Valley.

The California Data Exchange Center (CDEC) has estimates of unimpaired flow at four locations in the Upper San Joaquin River Basin. Since 1980, estimates of unimpaired flow are only provided at San Joaquin River below Friant Dam, where the annual average unimpaired runoff is about 1,800 TAF. As indicated on Table 2-1, annual runoff from the Upper San Joaquin River Basin (at Friant Dam) varies widely, ranging from a recorded low of about 362 TAF in 1977 to a recorded high of 4,642 TAF in 1983.

TABLE 2-1
SUMMARY OF RUNOFF IN THE UPPER SAN JOAQUIN RIVER BASIN

Station (CDEC ID)	Record Period	Annual Runoff (acre-feet)		
		Maximum	Average	Minimum
Big Creek below Huntington Lake (BHN)	2/1905 – 9/1980	297,800	110,640	14,363
San Joaquin South Fork near Florence (SFR)	10/1900 – 9/1980	248,864	652,500	71,306
San Joaquin River at Mammoth Pool (SJM)	10/1905 – 9/1980	2,964,120	1,323,776	307,870
San Joaquin River below Friant Dam (SJF)	10/1900 – present	4,641,880	1,830,331	361,550
Source: California Data Exchange Center (CDEC)				

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FIGURE 2-1. STUDY AREA EMPHASIS

Surface Water Resources in the Study Area

The east side of the San Joaquin Valley includes numerous streams and rivers that drain the western slope of the Sierra Nevada Mountains into the Central Valley. During the past 50 years, water resources on all major rivers have been developed through the construction of dams and reservoirs for water supply, flood control, and hydropower generation purposes. Table 2-2 provides a summary of major reservoirs in the eastern San Joaquin Valley. With the exception of the San Joaquin River, the table lists only the largest water supply and flood control reservoir on each river.

The largest reservoir on the San Joaquin River is Millerton Lake, formed by Friant Dam. These facilities are part of the Friant Division of the Central Valley Project (CVP), and their operation significantly affect the flow in the San Joaquin River. Inflow to Millerton lake is influenced by the operation of several upstream hydopower generation projects. Dams and reservoir upstream of Millerton Lake are identified on Table 2-2 and shown in Figure 2-2.

Friant Division of the CVP

The Friant Division of the CVP provides water to over one million acres of irrigable land on the east side of the southern San Joaquin Valley, from near the Chowchilla River in the north to the Tehachapi Mountains in the south. The principal features of the Friant Division were completed in the 1940s, including Friant Dam and Millerton Lake located northeast of Fresno on the San Joaquin River; and the Madera and Friant-Kern canals, which convey water north and south to agricultural and urban water contractors. Figure 2-3 shows locations of water districts in the San Joaquin Valley.

Millerton Lake, the largest reservoir in the Upper San Joaquin River Basin has a storage capacity of 520,500 acre-feet and is operated to provide water supply to agricultural and urban areas in the eastern San Joaqun Valley and for flood control on the San Joaquin River. Minimum storage for canal diversion is about 130,000 acre-feet, resulting in active conservation storage of about 390,500 acre-feet.

During the flood season of October through March, up to 170,000 acre-feet of available storage space must be maintained for control of rain floods. Under present operating rules, up to 85,000 acre-feet of flood control requirement in Millerton Lake may be provided by an equal amount of space in Mammoth Pool (Figure 2-4).

The limited active conservation storage and the requirement for flood space reservation result in very little opportunity for carryover storage operations. Thus, Millerton Lake is operated as an annual reservoir with no specific provision for carryover storage. Annual water allocations and release schedules are developed with the intention of lowering reservoir storage to minimum levels by the end of September. In cases where demands are lower or inflow is greater than typical, end of year storage may be above minimum levels resulting in incidental carry over storage.

TABLE 2-2
RESERVOIRS ON THE EAST SIDE OF THE SAN JOAQUIN VALLEY

Reservoir Name	River or Creek	Owner	Storage (acre-feet)	Year	Operational Objectives				
					FC	WS	HP	RF	WQ
Reservoirs in the San Joaquin River Watershed									
Millerton Lake	San Joaquin River	USBR	520,500	1942	X	X			
Kerckhoff	San Joaquin River	PG&E	4,200	1920			X	X	
Redinger	San Joaquin River	SCE	35,000	1951			X	X	
Florence Lake	San Joaquin River South Fork	SCE	64,404	1926			X	X	
Huntington	Big Creek	SCE	88,834	1917			X	X	
Shaver	Stevenson Creek	SCE	135,283	1927			X	X	
Thomas Edison	Mono Creek	SCE	125,000	1954			X	X	
Mammoth Pool	San Joaquin River	SCE	123,000	1960			X	X	
Reservoirs in the Other San Joaquin Valley Watersheds									
New Melones	Stanislaus River	USBR	2,420,000	1978	X	X	X	X	X
Don Pedro	Toulumne River	MID/TID	2,030,000	1970	X	X	X	X	
Lake McClure	Merced River	MID	1,025,000	1967	X	X	X	X	
Eastman Lake	Chowchilla River	USACE	150,000	1975	X	X			
Hensley Lake	Fresno River	USACE	90,000	1975	X	X			
Pine Flat	Kings River	USACE	1,000,000	1954	X	X			
Kaweah[1]	Kaweah River	USACE	143,000	1962	X	X			
Success[1]	Tule River	USACE	82,300	1961	X	X			
Isabella	Kern River	USACE	568,000	1953	X	X			

[1] Enlargement of Kaweah and Success lakes has been authorized. Table reflects existing capacity

Owners
- USBR U.S. Bureau of Reclamation
- USACE U.S. Army Corps of Engineers
- SCE Southern California Edison
- PG&E Pacific Gas and Electric
- MID/TID Modesto Irrigation District and Turlock Irrigation District
- MID Merced Irrigation District

Operational Objectives
- FC Flood control – these reservoirs have dedicated flood control storage space
- WS Water supply for irrigation, domestic, municipal, and industrial uses
- HP Hydropower generation
- RF Downstream river instream flow requirements
- WQ Delta water quality

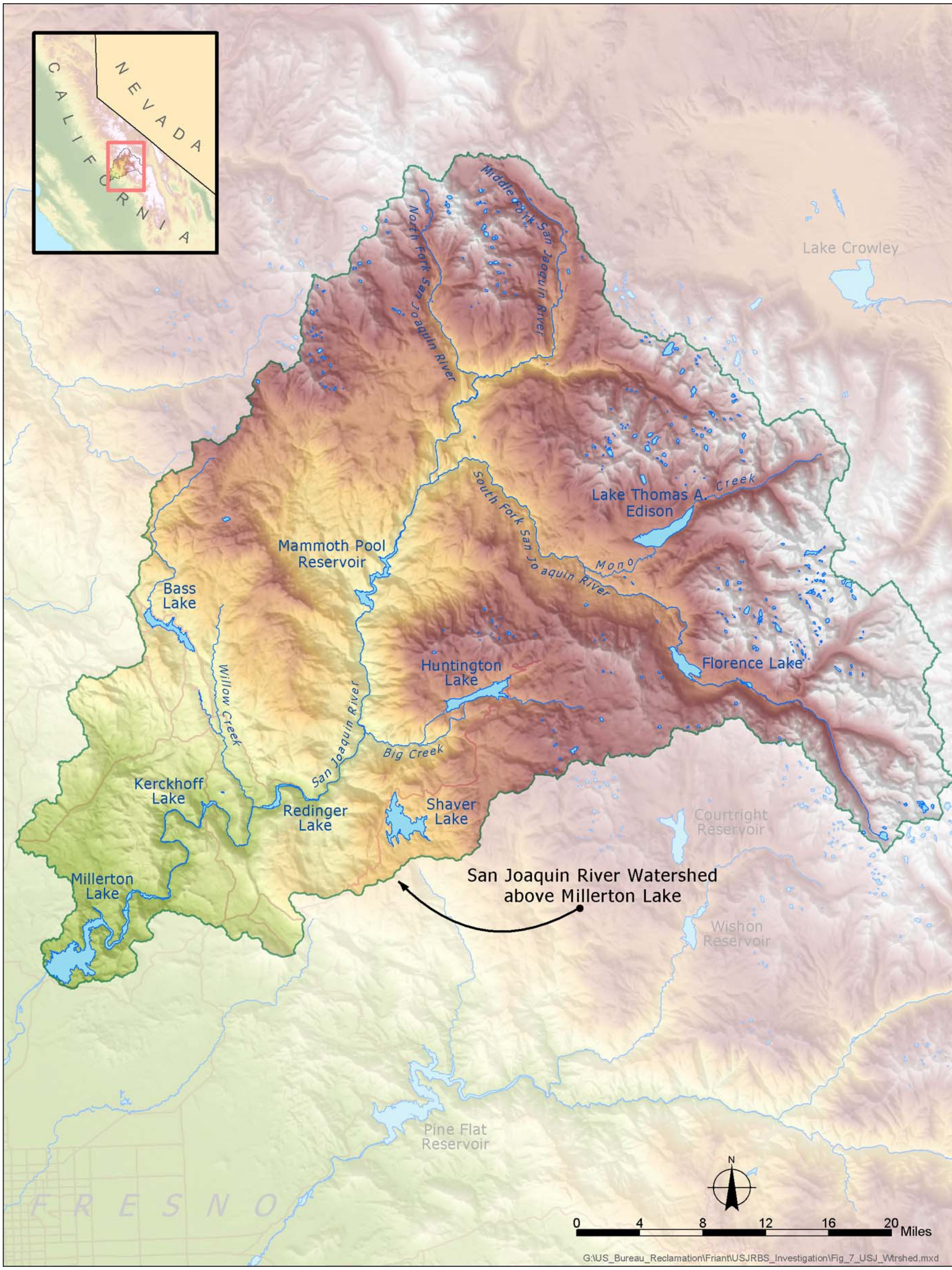

FIGURE 2-2. FACILITES UPSTREAM OF MILLERTON LAKE

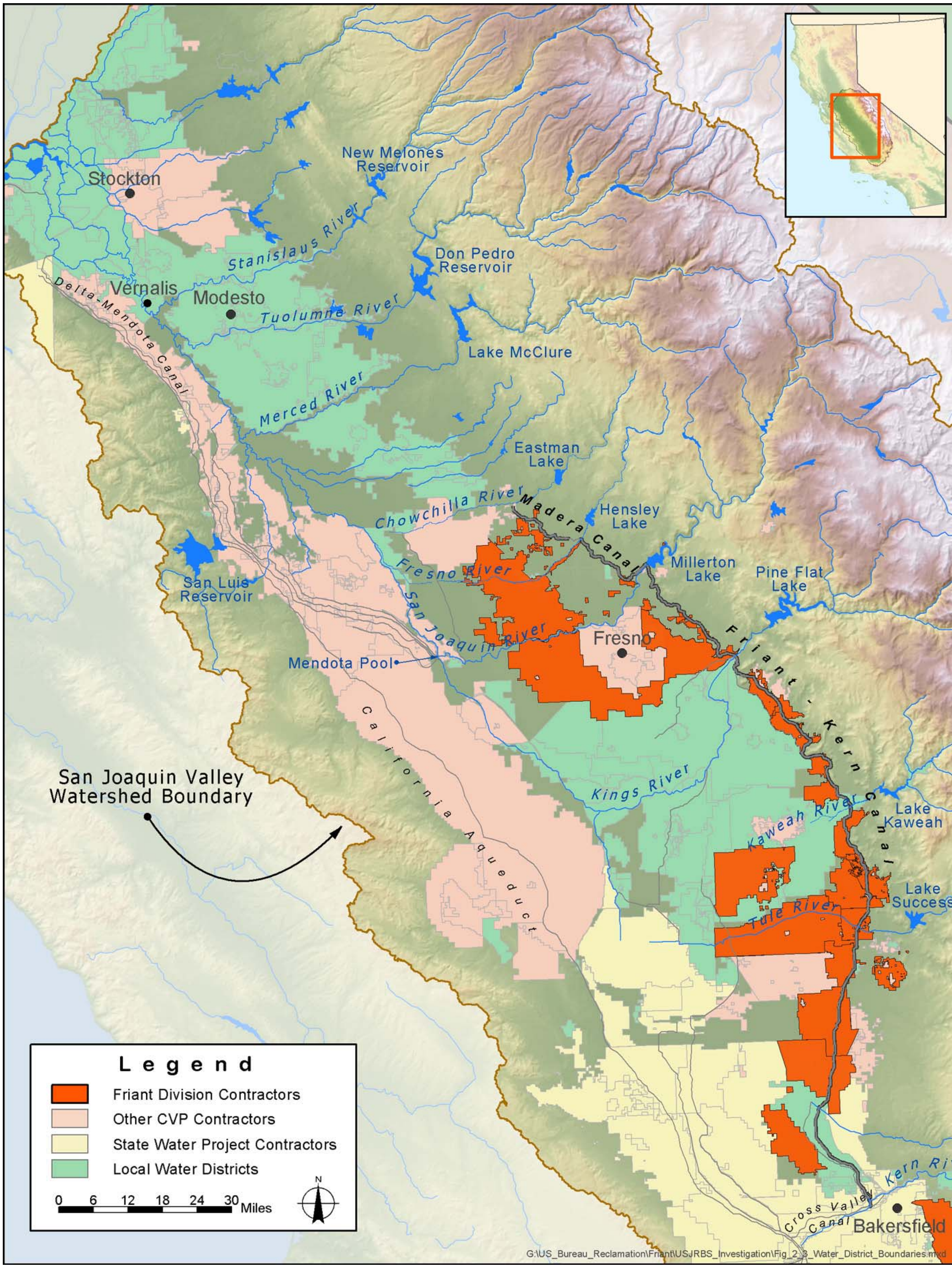

FIGURE 2-3. WATER DISTRICTS IN THE SAN JOAQUIN VALLEY

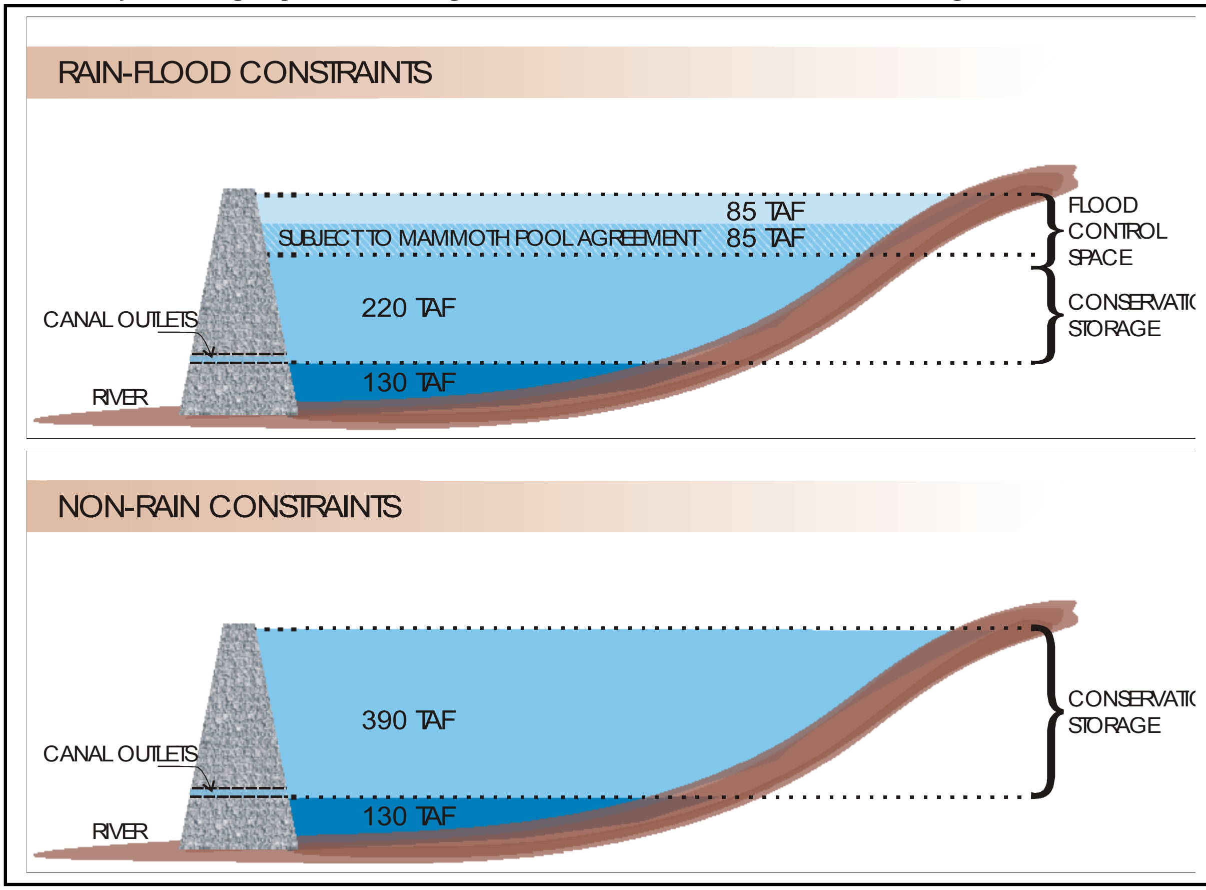

FIGURE 2-4. SCHEMATIC OF RESERVOIR STORAGE REQUIREMENTS

Reclamation obtained the majority of the water rights to the San Joaquin River allowing for the diversion of water at Friant Dam through purchase and exchange agreements with individuals and entities that held those rights at the time the project was developed. The largest of these agreements requires annual delivery of approximately 800,000 acre-feet of water to the Mendota Pool to serve water rights holders along the San Joaquin River. This obligation is met with water exported from the Delta via the Delta-Mendota Canal in accordance with in the San Joaquin River Exchange Contracts. If Delta water is not available to meet these commitments, Reclamation would be required to release water from Friant Dam to meet San Joaquin River water rights obligations. With the exception of flood control operations, water released from Friant Dam to the San Joaquin River is limited to that necessary to satisfy seepage losses and riparian water rights along the San Joaquin River between Friant Dam and the Gravelly Ford.

Friant Division Contract Types and Water Deliveries

The Friant Division was designed and is operated to support conjunctive water management in an area that was subject to groundwater overdraft prior to construction of Friant Dam and remains in a state of overdraft today. Reclamation employs a two-class system of water allocation to take advantage of water during wetter years. Friant Division contract amounts for each contractor are listed in Table 2-3.

Class 1 contracts, which are based on a firm water supply, are generally assigned to municipal and industrial (M&I) and agricultural water users that have limited access to good quality groundwater. These lands primarily include upslope areas planted in citrus or deciduous fruit. During project operations, the first 800,000 acre-feet of annual water supply is delivered under Class 1 contracts.

Class 2 water is used as a supplemental supply and is delivered directly for agricultural use or for groundwater recharge, generally in areas that experience groundwater overdraft. Class 2 contractors typically have access to good quality groundwater supplies and can continue to operate with recurrent deficiencies by using groundwater. Many Class 2 contractors are in areas with high groundwater recharge capability and operate dedicated groundwater recharge facilities. The location of water districts in the San Joaquin Valley, including Friant Division contractors, is shown in Figure 2-3.

In addition to Class 1 and Class 2 water deliveries, Reclamation is authorized to deliver water that would otherwise be released for flood control purposes. Section 215 of the Reclamation Reform Act of 1982 authorizes the delivery of unstorable irrigation water that would be released due to flood control criteria or unmanaged flood flows. The delivery of Section 215 water has enabled groundwater replenishment at levels higher than Class 1 and Class 2 contract deliveries would support in the southern San Joaquin Valley.

TABLE 2-3
HISTORICAL FRIANT ALLOCATIONS

Year	Class 1 Contract	Class 2 Contract
1957	100%	0%
1958	100%	0%
1959	100%	0%
1960	100%	0%
1961	75%	0%
1962	100%	62%
1963	100%	80%
1964	100%	12%
1965	100%	99%
1966	100%	23%
1967	100%	99%
1968	54%	0%
1969	100%	99%
1970	100%	29%
1971	100%	35%
1972	100%	40%
1973	100%	76%
1974	100%	81%
1975	100%	59%
1976	75%	0%
1977	25%	0%
1978	100%	99%
1979	100%	62%
1980	100%	98%
1981	100%	22%
1982	100%	98%
1983	100%	98%
1984	100%	49%
1985	100%	14%
1986	100%	93%
1987	91%	0%
1988	78%	0%
1989	98%	0%
1990	68%	0%
1991	100%	0%
1992	83%	0%
1993	100%	90%
1994	80%	0%
1995	75%	100%
1996	100%	55%
1997	100%	30%
1998	91%	10%
1999	100%	20%
2000	100%	17%
2001	100%	5%
2002	100%	8%

Source: Friant Water Users Authority

Historically, the Friant Division has delivered an average of about 1.3 million acre-feet of water annually. Releases from Friant Dam to the San Joaquin River for downstream riparian right holders and flood control purposes average about 530,000 acre-feet per year, however, this average annual amount is strongly influenced by large flood releases in a few years. The median annual release to the San Joaquin River from Friant Dam since 1949 has been about 129,000 acre-feet, which is slightly higher than approximately 117,000 acre-feet that required to meet downstream water right diversions above Gravelly Ford and account for seepage. The historical allocation of water to Friant Division contractors, expressed as a percentage of total amounts of Class 1 and Class 2 contracts (Table 2-4) varies widely in response to hydrologic conditions.

During the period from 1957 through 2001, annual allocations of Class 1 water typically have been at or above 75 percent of contract amount, except in three extremely dry years. In this same period, full allocation of Class 2 water supplies occurred in about one fourth of the years.

During the extended drought from 1987 through 1992, no Class 2 water was available and Class 1 allocations were below full contract amounts, except in one year. During this and other historical drought periods, water contractors relied heavily on groundwater to meet water demands.

In addition to the Class 1, Class 2, and conjunctive management aspects of the Friant Division operations, a very productive program of transfers between districts takes place annually. This program provides opportunities to improve water management within the Friant service area. In wet years, water that is surplus to one district's need can be transferred to other districts that have the ability to recharge groundwater. Conversely, in dry years, water is returned to those districts that have little or no groundwater supply, thereby providing an ongoing informal groundwater banking program within the Friant Division.

The Cross-Valley Canal, a locally-financed facility completed in 1975, enables delivery of water from the California Aqueduct to the east side of the southern San Joaquin Valley near the City of Bakersfield. A complex series of water purchase, transport, and exchange agreements allow for the exchange of equivalent amounts of water between Arvin-Edison Water Storage District (a long-term Friant contractor) and eight entities that hold CVP contracts for CVP water exported from the Delta.

When conditions permit, water can be is delivered to Arvin Edison from the California Aqueduct in exchange for water that would have been delivered from Millerton Lake. Through the exchange agreements, up to 128,300 acre-feet annually can be delivered to other Friant Division contractors.

TABLE 2-4
FRIANT DIVISION LONG-TERM CONTRACTS

CONTRACT TYPE/CONTRACTOR	Class 1	Class 2	Cross Valley Exchange
Friant-Kern Canal Agricultural			
Arvin-Edison WSD	40,000	311,675	
Delano-Earlimart	108,800	74,500	
Exeter ID	11,500	19,000	
Fresno ID		75,000	
Garfield WD	3,500		
International WD	1,200		
Ivanhoe ID	7,700	7,900	
Lewis Creek WD	1,450		
Lindmore ID	33,000	22,000	
Lindsay-Strathmore ID	27,500		
Lower Tule River ID	61,200	238,000	
Orange Cove ID	39,200		
Porterville ID	16,000	30,000	
Saucelito ID	21,200	32,800	
Shafter-Wasco ID	50,000	39,600	
Southern San Joaquin MUD	97,000	50,000	
Stone Corral ID	10,000		
Tea Pot Dome WD	7,500		
Terra Bella ID	29,000		
Tulare ID	30,000	141,000	
Sub-Total Friant-Kern Canal Agricultural	**595,750**	**1,041,475**	
Madera Canal Agricultural			
Chowchilla WD	55,000	160,000	
Madera ID	85,000	186,000	
Sub-Total Madera Canal Agricultural	**140,000**	**346,000**	
San Joaquin River Agricultural			
Gravelly Ford WD		14,000	
Total Friant Division Agricultural	**735,750**	**1,401,475**	
Friant Division M&I			
City of Fresno	60,000		
City of Orange Cove	1,400		
City of Lindsay	2,500		
Fresno County Water Works District No. 18	150		
Madera County	200		
Total Friant Division M&I	**64,250**		
Total Friant Division Contracts	**800,000**	**1,401,475**	
Cross Valley Canal Exchange Contracts			
Fresno County			3,000
Tulare County			5,308
Hills Valley I.D.			3,346
Kern-Tulare W.D.			40,000
Lower Tule River I.D.			31,102
Pixley I.D.			31,102
Rag Gulch W.D.			13,300
Tri-Valley W.D			1,142
Total Cross Valley Canal Exchange			**128,300**

Source: Friant Water Users Authority Informational Report

Facilities Upstream of Millerton Lake

Upstream of Millerton Lake, Pacific Gas & Electric (PG&E) and Southern California Edison (SCE) own and operate several dams and reservoirs for the primary purpose of hydropower generation. The operation of these facilities affects the flow of water into Millerton Lake and consequently affects the quantity and timing of available water for the Friant Division. The east side of the southern San Joaquin Valley also includes numerous other surface water reservoirs that were developed for flood control and water conservation and that deliver significant water supplies to the same general area as the Friant Division.

Groundwater Resources

The San Joaquin Valley Groundwater Basin is a structural trough up to 200 miles long and 70 miles filled with up to 32,000 feet of marine and continental sediments deposited during periodic inundation by the Pacific Ocean and erosion of surrounding mountains. Continental deposits form an alluvial wedge that thickens from the valley margins toward the axis of the structural trough, which is generally oriented along a north-south alignment.

Groundwater is a major source of agricultural and urban water supplies in the study area. The locations of groundwater basins underlying the San Joaquin Valley within the study area are shown in Figure 2-5. Typical groundwater production conditions for each sub-basin are listed in Table 2-5, based on information from DWR Bulletin 160-98. At a 1995 level of development, annual average groundwater overdraft is estimated at about 240,000 acre-feet per year in the San Joaquin River hydrologic region and at about 820,000 acre-feet per year in the Tulare Lake hydrologic region (Bulletin 160-98).

TABLE 2-5
PRODUCTION CONDITIONS IN SAN JOAQUIN VALLEY GROUNDWATER SUB-BASINS

Basin Number[1]	Basin Name	Extraction (TAF/year)	Well Yields (gpm)	Pumping Lifts (feet)
San Joaquin River Basin				
765	Modesto	230	1,000 – 2,000	90
776	Delta-Mendota	510	800 – 2,000	35 – 150
778	Turlock	450	1,000 – 2,000	90
784	Merced	560	1,500 – 1,900	110
795	Madera	570	750 – 2,000	160
796	Chowchilla	260	1,500 – 1,900	110
Tulare Lake Basin				
821	Kings	1,790	500 – 1,500	150
831	Westside	210	800 – 1,500	200 - 800
849	Kaweah	760	1,000 – 2,000	125 - 250
861	Tulare Lake	670	300 – 1,000	270
898	Tule	660	N/A	150 - 200
891	Pleasant Valley	100	N/A	350
1058	Kern	1,400	1,500 – 2,500	200 - 250
Source: California Department of Water Resources Bulletin 160-98. Note: 1) Groundwater basin number as shown on Figure 2-5.				

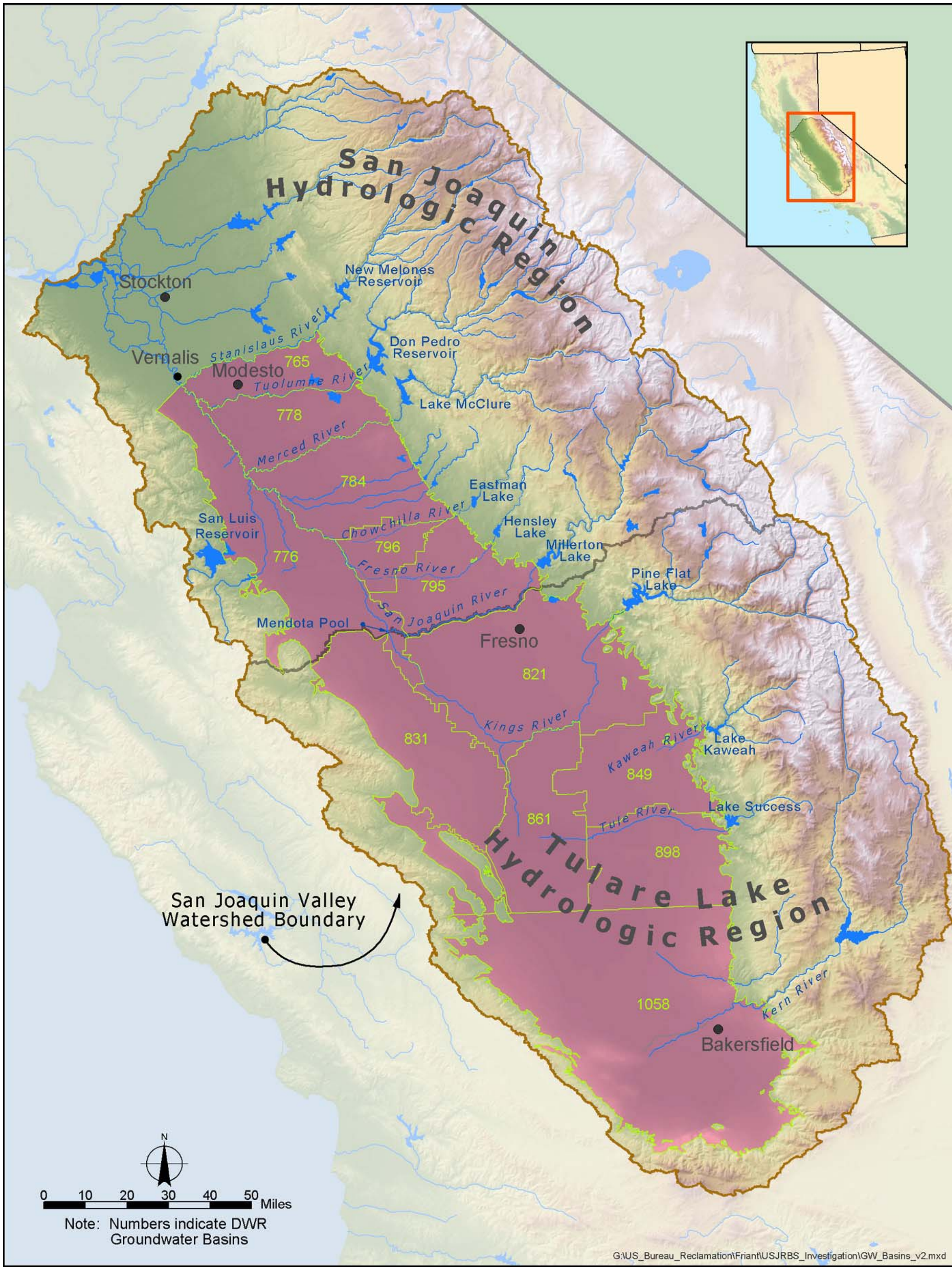

FIGURE 2-5. SAN JOAQUIN VALLEY GROUNDWATER SUB-BASINS IN THE STUDY AREA

FUTURE WITHOUT-PROJECT CONDITIONS

Water resources in the study area are not sufficient to meet the demands of current water uses. Local water users, CALFED, and numerous other entities have been considering potential projects and actions that would help meet current water needs, provide water for other purposes such as restoration of the San Joaquin River, and improve flood protection along the San Joaquin River. At this time, most of these initiatives are still under investigation and projects have not been sufficiently permitted, authorized, or funded to assure their completion and provide a basis for future planning.

The CALFED Program is developing a consistent set of assumptions regarding the definition of future without project conditions throughout the CALFED solution area. Those actions or projects that are foreseeable and certain during the planning time frame will be included in the future without-project condition. Assumptions regarding actions or projects that are foreseeable but not certain to be implemented during the planning time frame or the details of the implementation are not fully known at this time may also be considered for comparison purposes. Assumptions regarding such actions and projects may be included in an alternative alternate baseline for comparison or may be incorporated to project alternatives.

During the remainder of Phase 1, and during Phase 2 of the Investigation, assumptions regarding water demands, ecosystem needs, and other CALFED actions and projects will be further refined by CALFED agencies and project study teams. The following sections describe the approach that is under way in defining the future without project conditions for programs that could affect the availability and use of water in the Upper San Joaquin River Basin, including conjunctive management, demand management, and exchanges and transfers.

Conjunctive Management

The CALFED Program is preparing an inventory of potential locally-initiated conjunctive management projects based on information provided through grant and loan applications during the past few years. The inventory will identify those projects that would be developed independent of new surface storage. During Phase 2, the conceptual development of conjunctive management projects in the future without project condition will need to consider water sources, changes to existing project operations, conveyance needs, and effects on regional groundwater conditions.

Demand Management

The CALFED Program has made preliminary assumptions regarding actions that would be taken at the local level to reduce water demands or increase the use of existing supplies. Water conservation and recycling projects undertaken at the local would be developed to help reduce local water resources problems, such as water quality or groundwater overdraft, but would not result in a reduction in surface water demand. This assumption recognizes that surface water supplies are not adequate to meet current and future demands without an over-reliance on groundwater. Thus, demand management actions implemented consistent with the CALFED ROD would likely result in reduced groundwater pumping, but would not reduce demands for surface water from Friant Dam.

Exchanges and Transfers

Similar to the approach in developing assumptions regarding future conjunctive management, the CALFED Program will compile a list of potential exchanges and water transfers that could be implemented independent of new storage projects. This work is in the formative stage and as of this date, a list has not yet been developed. Criteria for determining which exchanges and transfers would be included in a future without-project condition have not been fully defined.

CHAPTER 3. PROBLEMS AND OPPORTUNITIES

The definition of water resources problems and opportunities provides a framework for plan formulation and helps establish a set of objectives that a project would attempt to meet. Water resources problems are related to changing water needs, hydrologic variations in water availability, and the limited ability of current facilities to store and convey additional water.

As stated in Chapter 1, the CALFED ROD identified three goals that could be addressed, in part, through the development of additional surface water storage in the Upper San Joaquin River Basin. These include: contribute to restoration of the San Joaquin River; improve water quality in the San Joaquin River; and facilitate conjunctive water management and water exchanges that improve the quality of water deliveries to urban communities. These goals were used to develop an initial list of problems to be addressed by the Investigation.

During Workshop #2, stakeholders provided input on what actions could be taken to reduce identified problems and to identify opportunities to address other needs in the study area. Through this process, a set of problems and opportunities were identified that have some potential to be addressed by the development of additional surface water storage in the Upper San Joaquin River Basin.

Problems that could be Addressed Through the Development of Additional Storage

- San Joaquin River ecosystem
- San Joaquin River water quality
- Water supply reliability

Opportunities Provided by the Development of Additional Storage

- Flood control
- Hydropower generation
- Recreation
- Delta inflow

The first two problems listed above are similar to objectives stated in the CALFED ROD for storage in the Upper San Joaquin River Basin. Due to the general nature of appraisal-level studies, initial evaluations will not include project-specific details about groundwater recharge projects or water exchanges. Therefore, for the purposes of this Phase 1 Investigation, the ability to address the CALFED goals of facilitating conjunctive water management and water exchanges will be accomplished –through an evaluation of water supply reliability. This refinement in problem definition recognizes the historical and on-going water supply problems in the area served by Friant Dam, made evident by long-term groundwater overdraft.

The above list also includes opportunities to address other regional needs that were not explicitly identified in the ROD but could be addressed through the development of additional storage. For example, the ROD did not specifically recommend that flood problems in the San Joaquin River Basin be reduced, although it did recognize the complimentary relationships between ecosystem restoration, water supply reliability, and flood damage reduction actions. In addition, the development of a surface water storage site may create opportunities for the development of hydropower generation and recreation facilities. It is also recognized that releasing additional water to the San Joaquin River could affect flows in the river as it enters the Delta, affecting both the volume and quality of Delta inflow. On the basis of this understanding, the three problems listed above will be the basis for initial plan formulation, and the opportunities will be evaluated as additional needs that could also be addressed through the development of additional surface water storage. Each of the problems and opportunities is described in more detail in the following sections.

San Joaquin River Ecosystem

The reach of the San Joaquin River from Friant Dam to the confluence with the Merced River does not support a continuous natural riparian ecosystem. Since completion of Friant Dam, most of the water supply in the River has been diverted for agricultural and urban uses with the exceptions of releases to satisfy riparian water rights upstream of Gravelly Ford and flood releases. Consequently, the reach from Gravelly Ford to Mendota Pool is often dry. Flows from the Mendota Pool to Sack Dam contain Delta water for delivery to the San Luis Canal Company and to State and federal refuges. Groundwater seepage is the primary source of flow below Sack Dam prior to the confluence with Salt Slough. The reach from Sack Dam to Bear Creek benefits from managed wetland development, whereas marshes have been drained between Bear Creek and the Merced River. The lack of reliable flows and water quality in the San Joaquin River results in ecosystem conditions that are generally considered unhealthy.

During the past few decades, societal views towards ecosystem health of rivers in the Central Valley and elsewhere in the nation have changed. Today, many people would prefer a sustainable ecosystem along the upper San Joaquin River. This shift in viewpoint is evident in the numerous programs that are addressing ecosystem restoration in the Central Valley and along the San Joaquin River as well as ongoing litigation between a coalition of environmental interests represented by the NRDC, and Reclamation and the FWUA *(NRDC v. Rodgers)*.

For several years, NRDC and FWUA have been discussing various river restoration ideas that could be used as part of a settlement of *NRDC v. Rodgers.* Resolution of *NRDC v. Rodgers* may include some degree of river restoration, including a flow requirement in the San Joaquin River below Friant Dam. To date, the Court has not yet issued a decision regarding flow requirements or restoration objectives in the San Joaquin River downstream of Friant Dam.

The CALFED Ecosystem Restoration Program (ERP) Plan also describes an ecosystem restoration vision for the San Joaquin River from Friant Dam to the Delta. The vision discusses the types of habitat that may be attainable in each river reach, and identifies actions that would contribute to ecosystem restoration and flood damage reduction along the river.

A group of local stakeholders has recently begun development of a restoration plan for the San Joaquin River. This effort is in its initial phases, and objectives for restoration have not yet been established.

A demand on the Friant system for river restoration could be established at some time in the future, although one is not in place today. The Investigation will begin with the assumption that no specific flow is required, but will consider how additional storage could be used to provide water supplies to support restoration of the San Joaquin River. The Investigation will maintain flexibility so that plan formulation could adjust if a river restoration requirement is established during the course of the Investigation.

San Joaquin River Water Quality

Water quality in various segments of the San Joaquin River has been a problem for several decades due to low flow, and discharges from agricultural areas, wildlife refuges, and municipal and industrial treatment plants. Initial locations of concern for water quality included areas near Stockton and at Vernalis, downstream of the Stanislaus River as the San Joaquin River enters the Delta. Over time, the requirements for water quality in the river have become more stringent, and the number of locations along the river at which specific water quality objectives are identified have increased.

In 1998, the Central Valley Regional Water Quality Control Board (CVRWQCB) adopted a Water Quality Control Plan for the Sacramento River and the San Joaquin River Basin (Basin Plan) as the regulatory reference for meeting the state and federal requirements for water quality control that are consistent with the designated uses of water. The Basin Plan lists existing and potential beneficial uses of the Lower San Joaquin River, including agricultural uses, municipal and industrial uses, recreation, fishery migration and spawning, and wildlife habitat. Specific water quality standards associated with the Lower San Joaquin River apply to boron, molybdenum, selenium, dissolved oxygen, pH, pesticides, and salinity. The Basin Plan is currently under its triennial review process for beneficial use and water quality standard updates.

One of the high priority issues of the review is the regulatory guidance for Total Maximum Daily Load (TMDL) standards at locations along the San Joaquin River. Section 303(d) of the Federal Clean Water Act (Act) requires the identification of water bodies that do not meet, or are not expected to meet, water quality standards, or are considered impaired, and then prioritized in the 303(d) list. The Act further requires the development of a TMDL for each listing.

The current list, approved by the USEPA, is the 1998 303(d) list, in which Mud and Salt Sloughs and the Lower San Joaquin River from Mendota Pool downstream to the Airport Way Bridge near Vernalis were listed as impaired water bodies. The pollutants or stressors include boron, chlorphrifos, DDT, diazinon, electrical conductivity, Group A pesticides,[1] selenium and other unknown toxics. A list of final dates for meeting TMDLs and implementing associated programs is expected to be considered by the CVRWQCB; at this time the dates are generally set at year 2011.[2]

CVRWQCB staff reports on the selenium TMDL and the salt and boron TMDL were completed in August 2001 and January 2002, respectively. The final report on

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[1] Group A pesticides include aldrin, dieldrin, chlordance, endrin, heptachlor heptachlor epoxide, hexachlorocyclohexane (including lindane), endosulfan and toxaphene.

[2] A delay of the final dates to year 2015 are proposed in the December 2001 report prepared by the CVRWQCB on the revision of the current 303(d) list. The report is currently under review by the SWRCB.

organophosphorus TMDL is expected in June 2003. A TMDL is also being prepared for dissolved oxygen in the Stockton Deep Water Ship Channel. Allocations are also likely to be conducted for the San Joaquin River between Mendota and Channel Point (the headwater of the Stockton Deep Water Ship Channel) for nutrients, algae, flow, and sediment.

The TMDL for salt and boron identifies load limits that were developed to attain water quality objectives in the San Joaquin River at Vernalis for irrigation and non-irrigation months. The TMDL includes a base load that would be associated with the lowest expected flow for a given month and water year type, as well as a real-time relaxation approach that could be applied when river flows exceed the assumed minimum levels. Implementation of the real-time relaxation criteria would require flow and quality monitoring at additional locations and the development of a coordinated operations plan for discharges from nearly 300,000 acres of irrigated agricultural land.

CRWQCB Resolution No. 5-01-236, regarding control of discharges from irrigated lands (dated September 7, 2001), stipulates that the CVRWQCB will evaluate the available information and make recommendations as to whether to proceed to adopt a new waiver with conditions or to control discharges through a more formal regulatory approach prior to 2003. Through the triennial review process, the CVRWQCB is preparing an amendment to the Basin Plan to further regulate the water quality upstream of Vernalis and in the Deep Water Ship Channel. Major efforts to meet water quality standards in the San Joaquin River will be required as a result of implementation of the TMDL allocation process.

Regulatory trends over the past several decades show that standards generally become more stringent as the understanding of pollutant effects increases and technology advances. The Basin Plan (including TMDL allocation) is subject to future review and revision. Although it is likely that future versions will address more restrictive water quality objectives than the current version, the existing water quality objectives will be used for the Investigation.

Stakeholder input has suggested that water quality in the San Joaquin River could be improved by delivering water stored in Millerton Lake to the San Joaquin River Exchange Contractors or the wildlife refuges that currently receive Delta water from Reclamation. The provision of better quality water to these areas may result over time in higher quality discharge to the San Joaquin River.

Surface Water Supply Reliability

As described in Chapter 2, the Friant Division of the CVP was authorized and is operated to provide surface water supplies to an area that is highly reliant on groundwater. The groundwater basins in the eastern San Joaquin Valley experiences overdraft in most years, i.e., more groundwater is pumped out than is replenished either naturally or artificially. Although water deliveries from Friant Dam help reduce groundwater pumping and contribute to groundwater recharge, the continued general downward trends of groundwater levels indicate that significant water supply reliability problems remain. A continued decline of groundwater levels can lead to an unsustainable situation due to increased pumping costs, the need to deepen or abandonment wells, and potential land subsidence.

Future operations of the Friant Division are anticipated to be similar to existing operations. Water supply reliability in some areas of the Central Valley will continue to be lower than historical levels and future long-term average water deliveries will likely be less than full contract amounts. The future without project assumptions for the ongoing CALFED studies are based on projected year 2030demand levels, which include anticipated urban growth in the San Joaquin Valley and Southern California.

Additional storage in the Upper San Joaquin River Basin could increase the reliability of surface water deliveries to CVP Friant Division contractors or other regional water users that could receive water through CVP facilities. Delivery of additional surface water could reduce groundwater pumping, or increase groundwater recharge, resulting in greater water supply reliability. Either general action would result in reduced groundwater overdraft conditions regionally, and would provide greater stability in regional water supplies. This improved reliability would increase opportunities for water exchanges with urban water users to improve the quality of urban water supplies.

Additional storage in the Upper San Joaquin River Basin could also allow higher quantities of water to be provided to Mendota Pool via the San Joaquin River if releases are made for ecosystem or water quality purposes. Increased deliveries to Mendota Pool could in turn reduce required deliveries of water to the Mendota Pool via the Delta-Mendota Canal, increasing the water supply reliability to other South-of-Delta water users.

Flood Control

Flood operations at Friant Dam are based on anticipated precipitation and snowmelt runoff and the operations of upstream reservoirs. During flood operations, releases from Friant Dam are maintained when possible at flows that could be safely conveyed through the San Joaquin River and Eastside Bypass. Generally, flood operations target releases at or below 8,000 cfs downstream of Friant Dam.

Major storms during the past two decades have demonstrated that Friant Dam, among many other dams in the Central Valley, may not provide the level of flood protection that was intended at the time the flood management system was designed. In January 1997, uncontrolled releases from Friant Dam resulted in levee failures and extensive flooding in downstream areas.

Recent preliminary evaluations by the U.S. Army Corps of Engineers (COE) suggest that Friant Dam could regulate larger storm events at non-damaging flows if the flood storage capacity in Millerton Lake or elsewhere in the Upper San Joaquin River Basin were enlarged. The development of new surface water storage capacity for water supply and other purposes would provide an opportunity to capture additional flood volume at times when the water supply storage space is vacated. During initial studies for this Investigation, changes in flood storage rules will not be considered. Rather, the effects of enlarged storage on flood protection using existing flood control space requirements will be identified. The results from this evaluation will help identify the extent to which flood control is considered in future studies.

Hydropower

Hydropower has long been an important element of California’s power supply. Because of the ability to rapidly increase and decrease power generation rates, hydropower has often been used to support peak power loads in addition to base power loads. As reservoir operations have changed during the past two decades to accommodate environmental and changing water demands, California's ability to rely on hydropower for meeting peak demands has reduced.

Recent power supply problems in California suggest that there is a shortage of peak electricity production capacity. As population increases and economic development continues, electricity demands are expected to increase. Although some new power generation capacity will likely come on-line in the future, it is reasonable to expect that that additional generation capacity will still be required.

The development of additional storage in the Upper San Joaquin River watershed could provide opportunities to increase hydroelectric energy production capacity. Increasing the height of Friant Dam, or the construction of other dams, would provide additional head for hydropower generation and in some cases create opportunities for pump-storage operations. Although the economic feasibility of hydropower-only projects may be limited, the development of new storage for water supply, water quality, and ecosystem restoration creates opportunities for the addition of hydropower features. A net increase in hydropower generation capacity would help address current and anticipated future problems in meeting peak and base loads.

Recreation

Demands for water-oriented recreational opportunities in the San Joaquin River Basin are high. Some of these demands are served by reservoirs on the eastern slope of the Sierra Nevada Mountains. As population increases in the San Joaquin Valley, recreational demands are expected to increase.

Additional storage in the Upper San Joaquin River watershed could provide opportunities to increase water-oriented recreation facilities, such as swimming, access points for various types of boating, and trail use. In addition, the release of water from Friant Dam to the San Joaquin River for ecosystem restoration or water quality objectives could also increase recreation opportunities along the river.

Opportunities to increase recreation will depend upon site-specific conditions at potential or existing reservoirs as well as river flows associated with operational scenarios. Specific recreational features that would be consistent with storage alternatives will be identified later in the planning process.

Delta Inflows

The San Joaquin River terminates at the Sacramento-San Joaquin Delta, through which most of California's surface water passes. Many competing demands are placed on the water that flows into the Delta, including water supplies for CVP and SWP users, water supplies for in-Delta and Bay Area users, and flows for ecological function and water quality in the Bay-Delta estuary. From the perspective of many Delta-dependent interests, available annual and seasonal flows are below desired levels.

The primary goals of the CALFED program are to improve ecosystem conditions in the Bay-Delta and water supplies in California. Several actions are needed to accomplish these goals, including increasing Delta inflow. Additional storage in the Upper San Joaquin River watershed could lead to increased magnitude, duration, or frequency of inflows to the Delta resulting from releases intended to improve the San Joaquin River ecosystem or water quality.

The frequency and magnitude of flows released from Friant Dam that would reach the Delta depends on assumptions regarding the use of the water at Mendota Pool and seepage to groundwater. Because of these uncertainties, new storage in the Upper San Joaquin River Basin would not likely be operated specifically to meet Delta flow and water quality objectives, but water released for other purposes, such as water quality or river restoration, could provide benefits to the Delta.

The Investigation will estimate potential Delta inflow effects by comparing changes in San Joaquin River flows at Vernalis. It is assumed that the Vernalis Adaptive Management Plan (VAMP) will continue into the future and that existing reservoirs in the San Joaquin River Basin will be operated in accordance with existing criteria. Increased flow at Vernalis could change conditions in the Delta resulting in both potential ecosystem and ancillary water supply reliability benefits. Potential ecosystem benefits include increased flow and water quality in South Delta channels. Ancillary water supply benefits include the potential for increased Delta exports and export reliability, improved Delta export water quality, and a reduction in water releases by other entities and streams to meet VAMP requirements.

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CHAPTER 4. PLAN FORMULATION

This chapter describes the status of the plan formulation process for the Investigation. This includes a description of the planning approach, development of the Phase 1 study purpose, initial evaluations to help further refine project objectives, consideration of surface storage options, an approach to define functional equivalence, and an concepts for preliminary alternatives development. Plan formulation is an on-going process that will continue to evolve, as results of technical studies become available and additional stakeholder input is received. The following sections describe the general approach that is being applied and presents results of preliminary evaluations that have completed to date.

Phase 1 Investigation Planning Approach

The Phase 1planning approach is designed to identify opportunities for water storage development, estimate the extent to which water resources problems could be addressed by new storage, and identify the types of users that would participate in the development of a storage project or program. As shown in Figure 4-1, the Investigation includes a multi-track process that includes the planning process, evaluation tools, operations studies, and assessment of potential storage options. A brief description of tasks in each of the tracks shown in Figure 4-1 is provided in the discussions that follow. To date, the Investigation has proceeded about half way through the second column in Figure 4-1.

Throughout the planning process, the Investigation is supported by input from CALFED agencies and stakeholders. Public outreach, which includes a series of workshops that provide periodic updates to stakeholders on the progress of the Investigation and to receive comments and suggestions on completed and planned work, is described later in this chapter.

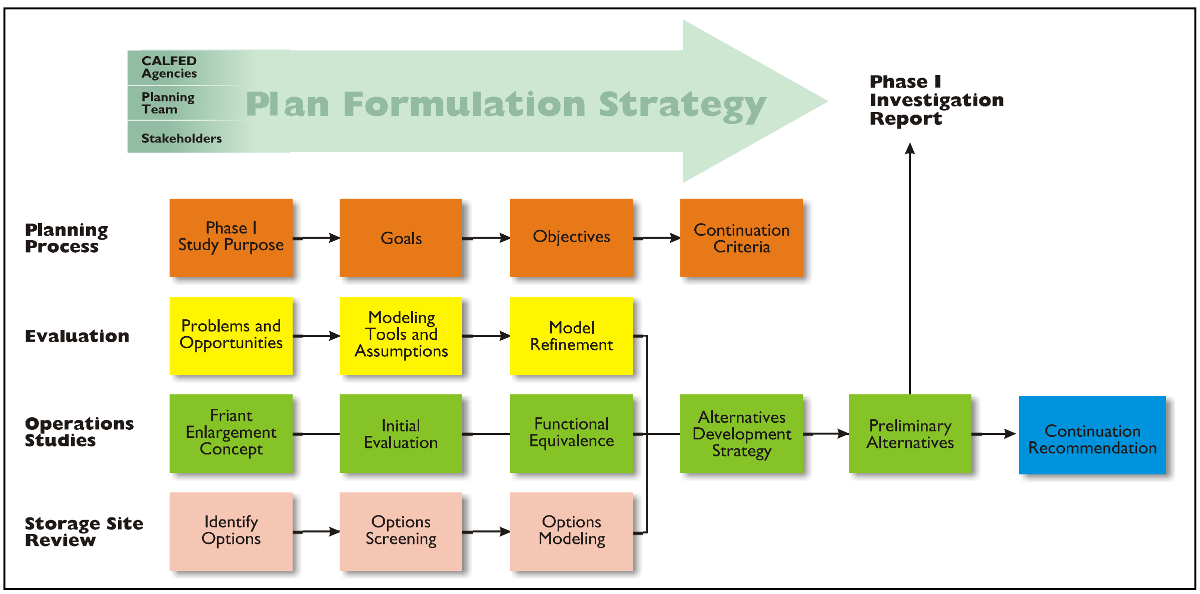

FIGURE 4-1. PHASE 1 INVESTIGATION PLANNING APPROACH

PLANNING PROCESS

The planning process began with a definition of the purpose for the Investigation. From that purpose, a set of goals was to be addressed were defined. The goals are general in nature and provide direction for the Investigation. As the planning process proceeds, however, objectives will be refined. Lastly, a set of continuation criteria will be developed and applied to results from technical studies to determine if continued study should be recommended for Phase 2.

Phase 1 Study Purpose

As explained in Chapter 3, the CALFED ROD provided guidance on initial problems to be addressed by the Investigation and a range of potential storage capacity to be considered. The ROD did not, however, provide quantitative objectives to be achieved or provide clarity on the how to identify a functionally equivalent storage program. As discussed previously, the Investigation is being conducted in a two-phase process. Phase 1 includes an appraisal-level evaluation to determine if additional study is warranted; Phase 2, if conducted, would include a feasibility study and related environmental compliance documentation to support project authorization. A draft study purpose statement has been developed to guide activities during Phase 1:

> ***"Determine if CALFED agencies should pursue a water storage feasibility study that could meet the CALFED goals for Upper San Joaquin River Basin storage and assist in solving other regional problems."***

As evident from the study purpose statement, a primary objective of Phase 1 is to complete technical studies sufficient to support a decision to continue with more detailed project development. At this time, the study team anticipates that decisions or recommendations to continue with preparation of a feasibility study would be made by Reclamation, DWR, CALFED management, and stakeholders who could be involved in project development. Although much of the information needed to support decisions by these parties is similar, the decision-making processes will vary from agency to agency. Agency-specific information will be required as technical studies are developed and results are presented. The strategy described below focuses on common information that would likely be needed to support decision-making by all interested parties.

Goals for Storage in the Upper San Joaquin River Basin

As discussed in Chapter 1, the goals for new storage in the Upper San Joaquin River Basin were presented in the CALFED ROD. These included: *"contribute to restoration of and improve water quality for the San Joaquin River and facilitate conjunctive water management and water exchanges that improve the quality of water deliveries to urban communities…*"The ROD also recommended that other regional water resources needs be considered in the development of projects. The problems and opportunities being addressed by the Investigation, as presented in Chapter 3, are consistent with CALFED goals and direction.

Planning Objectives

The general objectives for additional surface water storage in the Upper San Joaquin River Basin – additional water for river restoration, water quality, and water supply reliability – were described previously. More specific or quantitative objectives have not yet been established. Phase 1 studies are designed to help identify how storage could contribute to each goal. More specific objectives will be established during Phase 2.

Continuation Criteria

Later in Phase 1, when results from technical studies are more complete and a range of accomplishments can be displayed, two fundamental considerations will likely guide the decision to continue with more detailed study in Phase 2.

1. Can alternatives that meet CALFED ROD and participating agency goals be defined?
2. If so, what types of participants would be involved in continued study and potential project implementation?

These questions are very broad in nature and will be addressed with more detailed criteria. The first question will be evaluated using criteria related to a more specific definition of project goals and objectives. This will be accomplished through model simulations that identify how additional storage could address Investigation objectives and aid in addressing other regional water resources needs. Operations studies described in later sections will be used to guide this process. The second question will be addressed using criteria that focuses on issues of importance to Federal and state decision-makers, and potential user groups.

EVALUATION TOOLS

As described previously, the Phase 1 Investigation will identify amount of water supply that could be developed for each study objective with new storage. The CALSIM II model is being used to simulate water operations and estimate water quantities. CALSIM II was developed jointly by Reclamation and DWR to represent the integrated operation of water supply projects in the Central Valley.

Prior to the Investigation, the CALSIM II model included a highly generalized representation of the Friant Division that could not simulate changes in project operations in response to changes in demands or facility configurations. As part of this Investigation, the CALSIM II model was modified to reflect the decision-making process used to allocate water supplies at Friant Dam. The revised model includes logic that determines the allocation of Class 1 and Class 2 water supplies and the availability of Section 215 water for diversion to the Friant-Kern and Madera canals based on hydrologic conditions.

Historical operations demonstrate that the timing and pattern of demands for Class 1 and Class 2 water depend on the availability of Section 215 water and the total quantity of water allocated on an annual basis. The revised CALSIM II model logic applies water demand patterns for Class 1, Class 2, and Section 215 water supplies based upon calculated allocations. A description of CALSIM modifications and a comparison of the results to historical deliveries are included in Appendix A. As demonstrated in Appendix A, results from simulated operations compare closely with actual historical operations. The revised CALSIM II that includes Friant operations is used as a benchmark for the Investigation.

Operations Studies

The CALFED ROD indicated that the Investigation consider raising Friant Dam to increase storage in Millerton Lake by 250 TAF to 700 TAF, or develop a functionally equivalent storage program. A series of single-purpose evaluations, based on a representation of an enlarged Millerton Lake, are being used to define the extent to which additional storage could address Investigation objective and in part, to identify the functional equivalence of other storage options. To date, single-purpose evaluations have been made only for the Friant Enlargement Concept, as described below. Single-purpose model evaluations will be made for other storage options during the next few months.

Friant Enlargement Concept Single Purpose Evaluations

Initial model evaluation is based on a conceptual enlargement of Millerton Lake, and the use of additional water supply toward Investigation objectives. For these analyses, the storage capacity of Millerton Lake is increased by 700 TAF in the CALSIM II model, from the current capacity of 520 TAF to an enlarged capacity of 1,220 TAF. The model simulations are being run to identify the quantity of water that could be available for each Investigation purpose if the additional water supply created by new storage were operated solely to meet that purpose. The evaluations do not include any changes to the flood storage rules currently in place. Evaluations of different flood control rules would be included in Phase 2 studies.

The single-purpose evaluations for the Friant Enlargement Concept address the three goals of the Investigation – river restoration, water quality, and water supply reliability. Each single-purpose evaluation includes a generalized operation of the expanded reservoir to specifically address one project objective. Operations for one objective can also contribute to other project objectives and opportunities. For example, releases to the San Joaquin River for river restoration would also contribute to improved water quality in the river.

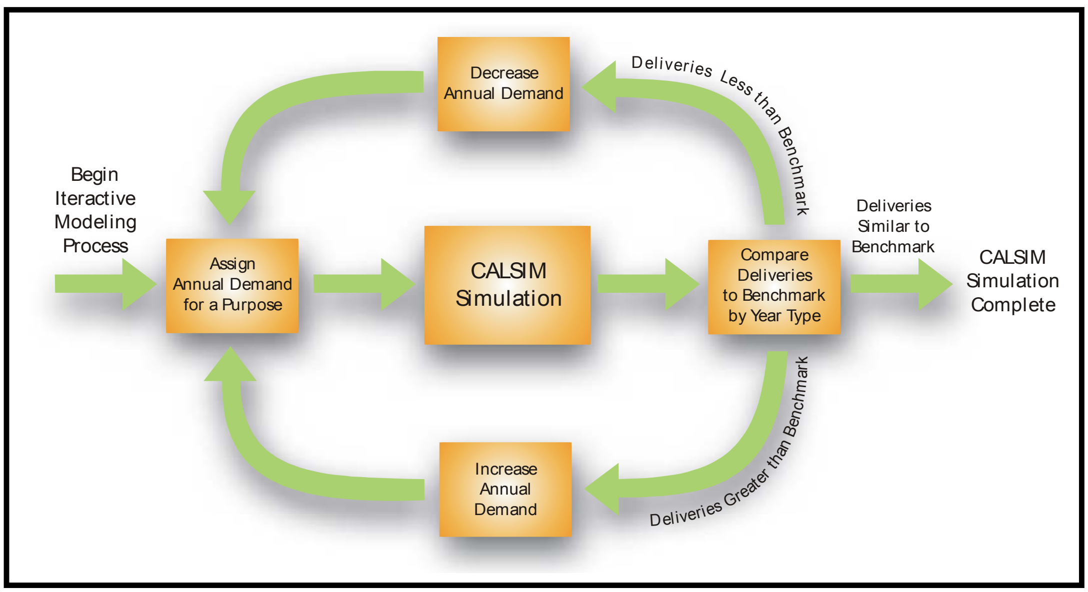

FIGURE 4-2. MODELING APPROACH FOR SINGLE-PURPOSE RIVER RESTORATION AND WATER QUALITY EVALUATIONS

Enlarging the storage capacity of Millerton Lake would result in year-to-year changes in water storage conditions, which would affect the amount of Class 1, Class 2 and Section 215 water that is available. To identify how new storage could contribute to project objectives without causing an unaccounted re-allocation of existing supplies, a modeling constraint was established.

The single-purpose evaluations for river restoration and water quality used an iterative approach, shown in Figure 4-2, to estimate the annual amount of water that would be available to the purpose without increasing or decreasing deliveries to current water users. For both the river restoration and water quality single-purpose evaluations, two model runs were made using different constraints to maintaining long-term annual water deliveries. Although neither scenario would result in the same distribution of water deliveries between the different classes of water as the benchmark simulation, the results provide initial information regarding the total amount of water that additional storage could provide.

Modeling Scenario 1 – This approach would maintain long-term average total annual deliveries over the simulation period. This approach applied a constant annual demand for either river restoration or water quality and compared the resulting long-term average deliveries to the benchmark simulation. The annual demand for restoration or water quality was modified until the long-tem average deliveries were similar. Although the long-term annual deliveries were similar between the single-purpose evaluations and the benchmark, this approach resulted in wide variations in the year-to-year distribution of annual deliveries, as compared to the benchmark. The results from this approach were presented to stakeholders, who requested modifications that would further limit the year-to-year variation of water deliveries.

Modeling Scenario 2 – This approach would maintain long-term average total annual deliveries by each water year type. Annual restoration and water quality demands for each year type were modified until a set of demands was established that would result in average deliveries for each year type similar to the benchmark. This approach resulted in a wide variation in the annual quantity of water that could be provided for restoration or water quality.

It is important to note that both modeling scenarios are based on the annual reservoir operational approach that is currently applied to Millerton Lake. In the calculation of annual water supply availability, the model assumes that minimum end-of-year storage would be at 130 TAF, or the approximate level of the canal outlets. If the enlarged reservoir were operated with an objective to carry-over water supply from one year to the next, the results presented in the following sections would differ. In particular, the wide variation in water quantities between different year types would be reduced and more water would likely be available during critically dry years.

The single-purpose evaluations described below identify an initial range of potential accomplishments that may be possible with the development of additional water storage. This range does not constitute a set of potential project alternatives and does not reflect the engineering and environmental issues that would be associated with the construction of an enlarged Friant Dam and Millerton Lake. Chapter 5 describes the preliminary engineering and environmental review of surface water storage sites, including the enlargement of Friant Dam and Millerton Lake.

San Joaquin River Restoration Single Purpose Evaluations

As described in Chapter 3, a flow requirement for restoration of the San Joaquin River cannot be determined at this time because a restoration objective has not been established. To determine how additional storage could provide water supplies to support restoration of the San Joaquin River, a range of ecosystem demands were placed on Millerton Lake. The model was run in an iterative manner until the constraints of maintaining long-term average annual water supply delivieries, as described above, was satisfied.

The monthly variation of flow (March through the following February) was based on the percentage distribution of monthly flows under an unimpaired condition. The variation of unimpaired flows for all year types was reviewed and found to be similar on a percentage basis. Therefore, the same percent distribution shown was used in all years. A summary of model results is presented in Table 4-1.

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TABLE 4-1. SUMMARY OF FRIANT ENLARGEMENT CONCEPT RIVER RESTORATION SINGLE-PURPOSE EVALUATIONS

Water Year Type	Annual Releases from Friant Dam for River Restoration (TAF)	Estimated Seepage to Groundwater (TAF)	Annual Volume Reaching Mendota Pool (TAF)
Modeling Scenario 1 – Constant Amount in all Water Years			
All year types	152	72	80
Modeling Scenario 2 – Variable Amount by Water Year Types			
Wet	252	72	180
Above Normal	142	72	70
Below Normal	92	72	20
Dry	212	72	140
Critically Dry	30	30	0

Notes:
Assume Millerton Lake storage at 1,220 TAF
Water year types based on San Joaquin River 60-20-20 Index
Hydrologic water year from October through following September
Water released from March through following February
Long-term simulation of monthly operations based on 1922 – 1994 hydrologic record

As noted in Table 4-1, some water released from Friant Dam for restoration purposes would seep to groundwater before reaching Mendota Pool. The San Joaquin River Habitat Restoration Plan estimated a monthly seepage amount of 6 TAF under constant flow conditions, which would total about 72 TAF on an annual basis. Although this water would not be available for restoration of the San Joaquin River below Gravelly Ford, it would help reduce groundwater overdraft in the area. Water that reaches Mendota Pool would be available to meet water demands. Most of the water identified in Table 4-1 that reaches Mendota Pool would reduce Delta demands by a similar amount and would contribute to improved water quality in the San Joaquin River, as described in the following section.

San Joaquin River Water Quality Single-Purpose Evaluations

As described in Chapter 3, water quality in the San Joaquin River could be improved if water is released from Friant Dam for delivery to Mendota Pool in lieu of Delta water. In general, water released from Friant Dam is of better quality than water exported from the Delta. An increase in the quantity of better quality water to Mendota Pool from Friant Dam, and a corresponding decrease of Delta water, would improve the quality of source water to agricultural and refuge areas. This in turn would result in improved quality of discharge to the San Joaquin River.

Two modeling scenarios were run for the Friant Enlargement Concept water quality single-purpose evaluation, as summarized in Table 4-2. Both scenarios were based on the assumption that water would be released from Friant Dam for water quality purposes during the three-month period of July through September, when water quality conditions in the San Joaquin River are most severe. Seepage to groundwater is based on an estimate of 12 TAF per month for intermittent flow conditions in the river provided by the San Joaquin River Habitat Restoration Plan.

TABLE 4-2. SUMMARY OF FRIANT ENLARGEMENT CONCEPT WATER QUALITY SINGLE-PURPOSE EVALUATIONS

Water Year Type	Annual Releases from Friant Dam for Water Quality (TAF)	Estimated Seepage to Groundwater (TAF)	Annual Volume Reaching Mendota Pool (TAF)
Modeling Scenario 1 – Constant Amount in all Water Years			
All year types	138	36	108
Modeling Scenario 2 – Variable Amount by Water Year Types			
Wet	286	36	250
Above Normal	136	36	100
Below Normal	51	36	15
Dry	176	36	140
Critically Dry	16	16	0

Notes:
Assume Millerton Lake storage at 1,220 TAF
Water year types based on San Joaquin River 60-20-20 Index
Hydrologic water year from October through following September
Water released from March through following February
Long-term simulation of monthly operations based on 1922 – 1994 hydrologic record

The San Joaquin River Exchange Contractors would use Friant water reaching Mendota Pool and the demand for Delta water at the Mendota Pool would be similarly reduced. Seepage to groundwater would help reduce groundwater overdraft in the area. Note that seepage estimates in critically dry years exceeds releases from Friant Dam for both the restoration flow and water quality evaluations. This results partially from the assumption that Friant would continue to be operated as an annual reservoir will not explicit carry-over requirements. Future simulations will address this generalization.

Water Supply Reliability Single Purpose Evaluations

Single-purposes evaluations for water supply reliability focused on increasing the amount of water delivered to meet current water delivery demands on Friant Dam. Water would be diverted to the Madera and Friant-Kern canals based on Class 1, Class 2, and Section 215 demands using the same logic as the benchmark simulation. The reservoir would be operated as an annual reservoir, with no explicit carry-over requirement. In effect, annual deliveries are based on the objective of delivering as much of the annual supply as possible. When annual supplies exceed annual demands, incidental carry-over would provide additional water for the following year.

Table 4-3 provides a summary of changes in total annual deliveries from Friant Dam for both the constant annual demand scenario and the water year variable scenario, as compared to the benchmark simulation. These quantities reflect the total of Class 1, Class 2, and Section 215 deliveries, but does not indicate how the relative delivery of water under these contract types differ. In general, deliveries of Class 1 water would increase in some, but not all, years when less than full Class 1 contract amounts would have been delivered in the benchmark scenario. Deliveries of Class 2 water also would increase, although these increases were partially offset by a reduction in Section 215 deliveries. Table 4-3 lists the net effect of these changes.

TABLE 4-3. SUMMARY OF FRIANT ENLARGEMENT CONCEPT WATER SUPPLY RELIABILITY SINGLE-PURPOSE EVALUATIONS

Water Year Type	Change in Annual Delivery from Friant Dam (TAF)
Modeling Scenario 1 – Constant Amount in all Water Years	
All year types	132
Modeling Scenario 2 – Variable Amount by Water Year Types	
Wet	178
Above Normal	93
Below Normal	106
Dry	247
Critically Dry	53
Notes: Assume Millerton Lake storage at 1,220 TAF Water year types based on San Joaquin River 60-20-20 Index Hydrologic water year from October through following September Water delivered from March through following February Long-term simulation based on 1922 – 1994 hydrologic record	

The total annual change in water supply shown in Table 4-3 does not account for potential reductions in deliveries to Mendota Pool or changes in groundwater seepage that result from reductions in the frequency of flood control releases from Friant Dam. These distinctions will be made in future evaluations.

Summary of Friant Enlargement Concept Single-Purpose Evaluations

The results of the single-purpose evaluations for river restoration and water quality are strongly influenced by assumptions regarding the preservation of current water uses. The use of long-term average annual deliveries results in a constant amount of additional water every year, but does not account for the resulting changes in conjunctive water management. Scenarios that vary the demand by water year type result in a wider range of annual water amounts that may more accurately reflect the variability of water supply that could result from additional storage.

As indicated in previous discussions, the enlargement of Millerton Lake by 700 TAF would increase the availability of water for each of the purposes evaluated. In general, the long-term average annual quantity of water for any purpose would range from about 75 TAF to over 150 TAF. The evaluations indicate that an annual amount ranging from 176 TAF to 247 TAF would be available during dry water years, depending on the single-purpose objective. However, these same simulations indicate that very little water would be available during critically dry years.

The wide variation in annual water amounts available for the three purposes is due, in part, to the operational assumptions applied to the initial evaluations. The operation of a larger Millerton Lake as an annual reservoir limits the availability of carry-over storage to cases where demands during wet and above normal years are less than total available supply. The unique succession of hydrologic water years from the 1922 through 1994 period of record contains more dry years than critically dry years following these situations. As a result, the additional water available from incidental carry-over storage is most beneficial in successive dry years.

While the use of annual reservoir operating logic may be adequate to demonstrate opportunities for additional conjunctive management of surface water and groundwater, it may not be well suited for an assessment of river restoration or water quality capabilities. Further refinement of reservoir operating objectives will be required to identify how water could be carried-over to successive years to support more consistent water quality and river restoration demands.

Detailed flood evaluations are not being made as part of the Phase 1 Investigation. However, monthly flood releases for the single purpose evaluations were compared to the benchmark scenario. In all three single-purpose evaluations, the increased storage capacity would reduce the frequency of months in which flood releases would be made to the San Joaquin River by about half the frequency of the benchmark scenario. The magnitude of flood releases by monthly volume in the single-purpose evaluations is also be lower than the magnitude of flood releases in the benchmark scenario, except during extremely wet years.

The calculation of flood control benefits of additional storage will be evaluated during Phase 2 studies. This will require the use of daily or hourly time-step models to identify peak flood flow rates and duration. Changes in downstream damages will be calculated using models that reflect the risk of flooding due to failures of the conveyance system.

APPRAISAL ANALYSIS OF SURFACE STORAGE OPTIONS

The CALFED ROD recommended that the Investigation consider enlarging Friant Dam and Millerton Lake or develop a functionally equivalent storage program that would increase available water supplies to support river restoration, improve river water quality, and increase water supply reliability. Alternatives to enlarging Millerton Lake by 700 TAF may include single facilities, or a combination of new and modified facilities that in combination provide functionally equivalent accomplishments. This section describes the approach being applied to identify and select potential storage sites for inclusion in project alternatives.

Storage Options Screening Approach

A review of previous regional water resources studies identified 16 potential surface storage options for initial consideration. This list included the enlargement of two existing reservoir (Lake Kaweah and Lake Success) that were dropped from further consideration in the Investigation because their enlargement has already been authorized for construction by the Corps of Engineers. The remaining 14 sites include a combination of enlargements to existing reservoirs and construction of new reservoirs. Some of the options are located in the Upper San Joaquin River Basin, others are located in watersheds that are served by the Friant Division or would be operated as off-canal storage along the Friant-Kern Canal.

Initial review of the storage sites focused on technical and environmental issues associated with the potential construction of each facility. This initial review has been completed, as described below, and is summarized in Chapter 5.

The next step will include operational modeling of retained options to identify how they could contribute to meeting project objectives. This work is beginning, and is described in general terms below. Following modeling of potential options, the storage sites will be compared on the basis of their ability to contribute to project objectives, cost, and potential environmental issues.

Initial Screening of Storage Site Options

Technical studies were conducted to identify engineering features and major issues of environmental concern that would be associated with each surface storage site. Chapter 5 of this report describes the scope of those efforts, summarizes the results of the analyses for each potential site, and presents recommendations regarding which surface storage options should be retained for further study. More detailed information is presented in a series of technical memoranda that were prepared for each storage site considered in the initial screening.

The initial screening focused on the potential construction-related issues of the surface storage options. The review attempted to determine if fundamental issues at any site would preclude the construction of the required facilities, prevent the developed water from being used, create environmental impacts that would be unmitigable, or create conditions under which permits by regulatory agencies or approved by decision-makers would be unlikely. Table 4-1 lists storage options that were identified, and the results of the initial review. A discussion of each site evaluated is included in Chapter 5.

TABLE 4-4
SUMMARY OF STORAGE OPTION INITIAL SCREENING RESULTS

Storage Option	Initial Review Results	Comments
Merced River Watershed		
Montgomery Reservoir	Dropped	Water quality concerns
San Joaquin River Watershed		
Friant Dam Enlargement	Retained	
Fine Gold Creek Reservoir	Retained	Pumped storage from Millerton Lake
Temperance Flat Reservoir	Retained	One potential dam site (RM279)
Kerckhoff Enlargement	Retained	
Mammoth Pool Enlargement	Retained	
"Big" Dry Creek Watershed		
Big Dry Creek Flood Detention Basin Modifications	Dropped	Retrofit of existing facility
Kings River Watershed		
Pine Flat Dam Enlargement	Retained	Exchange for Friant deliveries
Mill Creek Reservoir	Dropped	Environmental concerns
Rodgers Crossing Reservoir	Dropped	Recreation and other environmental concerns
Dinkey Creek Reservoir	Dropped	Recreation, land use, and other environmental concerns
Kaweah River Watershed		
Enlarge Lake Kaweah	In future without project	Authorized for construction by Corps of Engineers
Dry Creek Reservoir	Dropped	Environmental concerns
Yokohl Valley Reservoir	Retained	Off-canal storage
Tule River Watershed		
Enlarge Lake Success	In future without project	Authorized for construction by Corps of Engineers
Hungry Hollow Reservoir	Dropped	Foundation and environmental concerns

Modeling of Retained Options

Storage sites retained for further consideration following the initial review will be modeled to identify the extent to which they can contribute to project objectives. Each storage site will be represented in the simulation model to evaluate how it would be operated in combination with existing facilities to increase water supplies for the three primary purposes, as described previously. The analytical approach will be similar to the single-purpose evaluations described above in the Friant Enlargement Concept.

A schematic of CALSIM model modifications to support storage options modeling are shown in Figure 4-3. It should be noted that not all of the storage options retained in Table 4-4 are identified in the schematic. Rather, a generalized modeling approach will be used to represent potential sites based on how they would be integrated to the existing project.

Two reservoir nodes will be added upstream of Millerton Lake to represent Temperance Flat Reservoir and Kerchkoff Lake. Modifications to Mammoth Pool will be represented by a pre-processed operation that provides modified inflow to Millerton Lake. The simulation of Fine Gold Creek Reservoir includes a diversion facility for pumped storage. Water will be pumped from Millerton Lake into Fine Gold Creek Reservoir and drawn in later months.

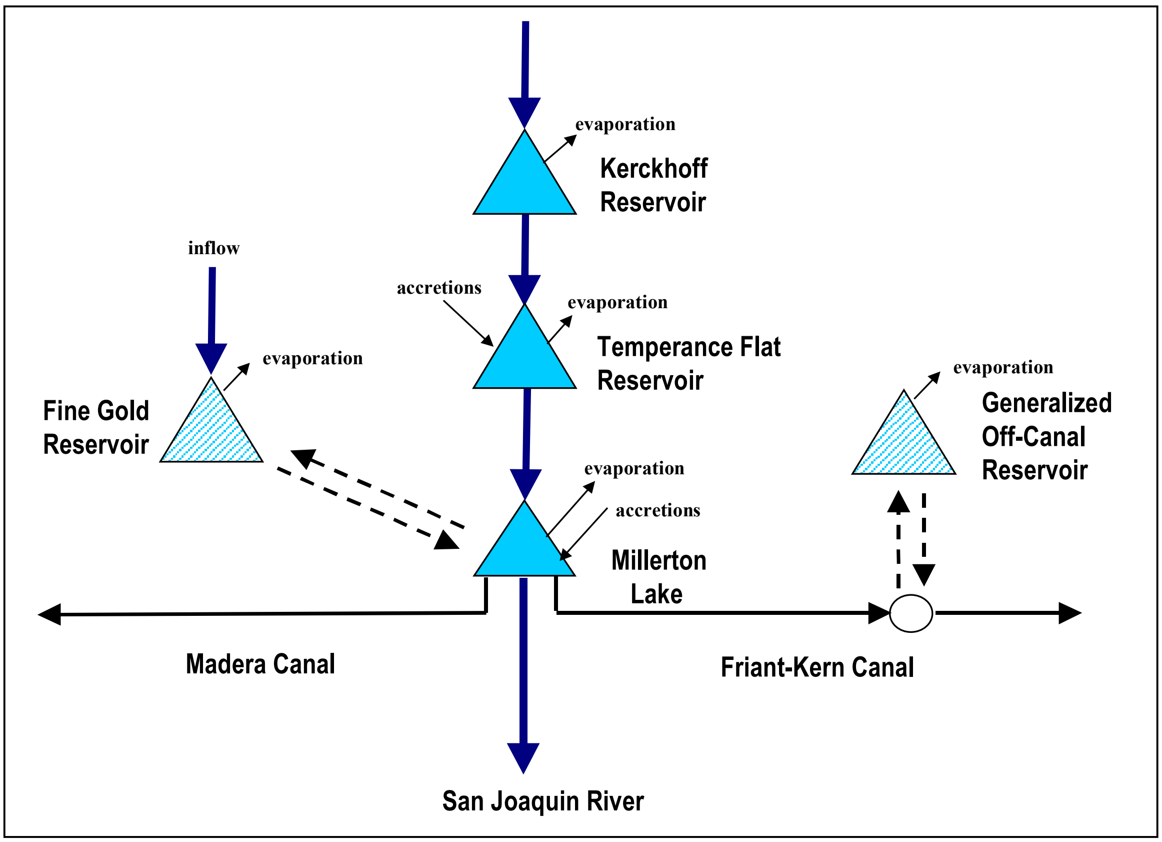

FIGURE 4-3. CALSIM SCHEMATIC FOR SIMULATION OF RETAINED STORAGE SITE OPTIONS

As indicated in Table 4-4, one potential reservoir site along the Friant-Kern canal, Yokhol Valley Reservoir was retained for operational evaluation. For initial evaluations, this site will be represented as a generic off-canal reservoir that will be sized to represent to different options under consideration. Assumptions regarding pumping capacity will be made to reflect the range of pumping considered. Water will be released from Millerton Lake and conveyed to these facilities by the Friant-Kern Canal during wet periods when canal capacity is available. At later times, water would be released from off-canal storage to contractors in lieu of releases from Millerton Lake.

The simulation of an enlarged Pine Flat Lake will be based on a generalized exchange scenario for coordinated Millerton Lake and Pine Flat operations. Early in the year, Millerton Lake water would be delivered to Pine Flat water users, thereby creating additional space in Millerton Lake to capture additional San Joaquin River flow. Similarly, the additional space in Pine Flat Reservoir would be available to store water that would have otherwise been delivered to contractors. Later in the year, Pine Flat water would be delivered to the Friant-Kern Canal in lieu of releases from Millerton Lake.

PUBLIC INVOLVEMENT DURING THE INVESTIGATION

As described in previous sections, the Investigation addresses issues of interest and concern to stakeholders engaged in local and regional water resources planning. The public involvement program features a series of interactive public workshops that enable stakeholders to provide input to the plan formulation and to stay informed regarding the planning process. The public involvement program also includes an outreach component to provide information and materials to a broad group of interested parties.

Stakeholder Workshops

The interactive component of the public involvement program includes a structured series of workshops and meetings held at various locations in the study area. The workshops provide opportunities to hear presentations by the project team, take part in discussions regarding plan formulation, and provide recommendations regarding the planning process, analyses, and project documents. To date, this process has included three general workshops and one topic-oriented working session. Figure 4-4 depicts the workshop series, which is designed to provide opportunities for involvement at key milestones in the planning process. The topics covered in each workshop were selected to provide updated information to stakeholders and receive important and timely input to the Investigation.

Participants in the workshop series include representatives of water agencies; counties; State and Federal agencies; water districts; environmental interest groups; and others with an interest in the Investigation. Detailed summaries of the workshops are prepared, distributed to the participants, and posted on the project website. The following descriptions briefly summarize workshops completed to date.

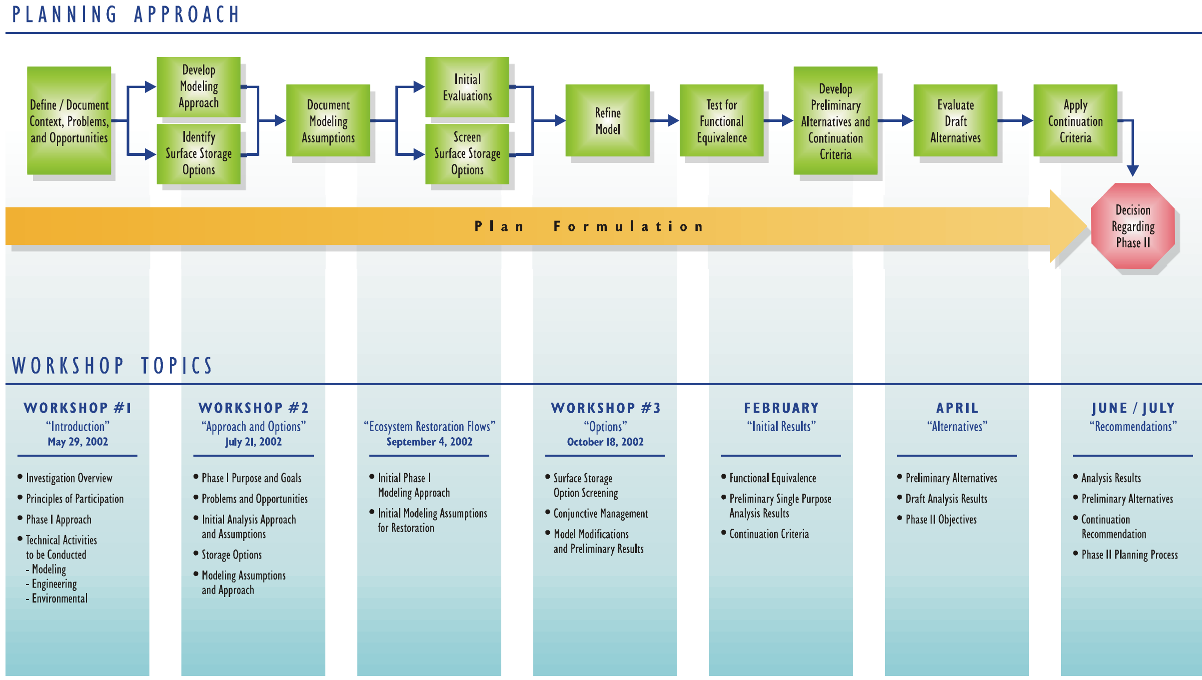

FIGURE 4-4. STAKEHOLDER WORKSHOPS

Workshop 1 – Introduction

The initial workshop, held on May 29, 2002 in Fresno, initiated the stakeholders' participation in the Investigation. The workshop included presentations and discussions on the objectives of the Investigation and included a review of the origins and authorities for the study. The project team presented the Phase I approach and explained the types of water resources problems that the Investigation would focus on during analyses. During a brainstorming session, participants described problems that they felt the study should address, and noted special considerations for the planning process. The plan for technical activities was also presented.

Workshop 2 – Approaches and Options

Workshop 2, held on July 31, 2002 in Modesto, provided an overview of the study approach and clarified the goals of the Investigation. Prior to the workshop, participants were provided a description of water resources problems and opportunities as they relate to the Investigation (See Chapter 3). Presentations and discussions centered on this information. Participants commented on the approach for addressing water quality, ecosystem, and water supply reliability problems and discussed the initial analysis concept (See Chapter 4). The project team presented a preliminary list of storage options identified in the Investigation. Additional presentations introduced the hydrologic models and modeling assumptions that would be used for Investigation analyses. During this workshop, a need was identified for a separate discussion of Friant Dam release patterns to use in the initial evaluation of ecosystem restoration opportunities. This separate discussion was held at an Ecosystem Restoration Flows workshop, described below.

Working Session – Ecosystem Restoration Flows

An working session focused on Ecosystem Restoration Flows was held on September 4, 2002 in Madera. Because many participants in this meeting had not attended previous Investigation workshops, this meeting included a review of the Investigation's goals and approach. Presentations covered the hydrologic model to be used, the assumptions and constraints in the model, and information needs. Participants provided recommendations and information, where possible, to aid in identifying the appropriate Friant Dam release patterns for inclusion in Investigation analyses.

Workshop 3 – Storage Options and Modeling Overview

Workshop #3, held on October 18, 2002 in Los Banos, updated participants on the Investigation progress and presented preliminary results of option screening and model simulations. Presentations covered the Investigation's context within the CALFED program and explained the formal review process to be used for study documents. The project team provided the draft results of the Investigation's initial surface storage option screening. (See Chapter 5 for descriptions of the options and a summary of the screening process). A presentation and accompanying facilitated discussion centered on the interrelationship of the conjunctive Water Management Program and its integration with the Investigation. The modeling team described modifications to the hydrologic model and provided a sample of analysis results.

Future Workshops

Public participation in the Investigation will continue throughout Phase I. Future public workshops will address hydrologic modeling analysis results, descriptions of preliminary alternatives, and the study continuation recommendations.

Public Outreach

The outreach component of the public involvement program includes mailings and e-mail notifications of project announcements and materials, along with a project website3 that makes project documents and data available publicly. In addition, project representatives correspond with interested groups and individuals and provide briefings to share information and answer questions as requested.

[3] http://www.mp.usbr.gov/sccao/storage

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CHAPTER 5. SURFACE STORAGE OPTIONS

This chapter summarizes the initial screening of the surface storage options. As described in Chapter 4 (Table 4-4), 16 potential sites were identified early in the study, of which, two would be expanded in the future-without-project condition. Figure 5-1 shows the locations of the remaining 14 sites that were reviewed in the initial screening.

The findings presented in this chapter are based on a preliminary review of the technical feasibility of constructing facilities at the candidate sites. The assessment was conducted at a reconnaissance level of detail, consistent with the scope of Phase 1 of the Investigation. The evaluation team included engineers and geologists that addressed design and construction issues, and environmental specialists that identified the range of likely environmental impacts and gaged at a very preliminary level the potential to mitigate adverse impacts.

Surface storage options that are retained after this initial screening will be further evaluated using hydrologic models to determine the extent to which they could contribute toward meeting the project goals. The initial screening ensures that future Investigation resources are directed only at options that appear reasonable to consider further.

METHODOLOGY

The screening began with a review of previous studies. In some cases, potential facilities described in previously studied were based on different configurations than those considered for this study. In such cases, features that were not relevant to the configuration under review were deleted. Similarly, features necessary for the configuration considered in this study were added. Conceptual engineering plans were developed for sites where no previously developed plans had been developed.

Figures 5-2 and 5-3 provide conceptual representations of major design and construction elements of a surface water storage project that were considered for a reservoir enlargement or construction of a new reservoir, respectively. Institutional and operational issues such as future sponsorship, ownership, operational responsibilities, or the allocation of developed water among potential project purposes has not been considered.

A Technical Memorandum (TM) was prepared for each storage option site. Each TM describes existing facilities, configurations and design characteristics, and relevant engineering and environmental issues. Engineering issues considered include geologic conditions, construction access, potential sources of construction materials, and impacts to existing infrastructure. Environmental issues considered include potential impacts to terrestrial and aquatic vegetation and wildlife, recreational resources, and land uses. Initial screening did not include consultations with environmental, resource, or permitting agencies.

SITE SPECIFIC SURFACE STORAGE OPTIONS

The screening of potential surface storage sites in this chapter proceeds from north to south, organized by major watershed within the study area. For each site, the proposed facilities are briefly described, major issues related to engineering and environmental findings are identified, and a determination is made regarding which options at the site, if any, will be retained for further consideration. The site-by-site results of the preliminary screening are summarized again in Table 5-2, at the end of the chapter.

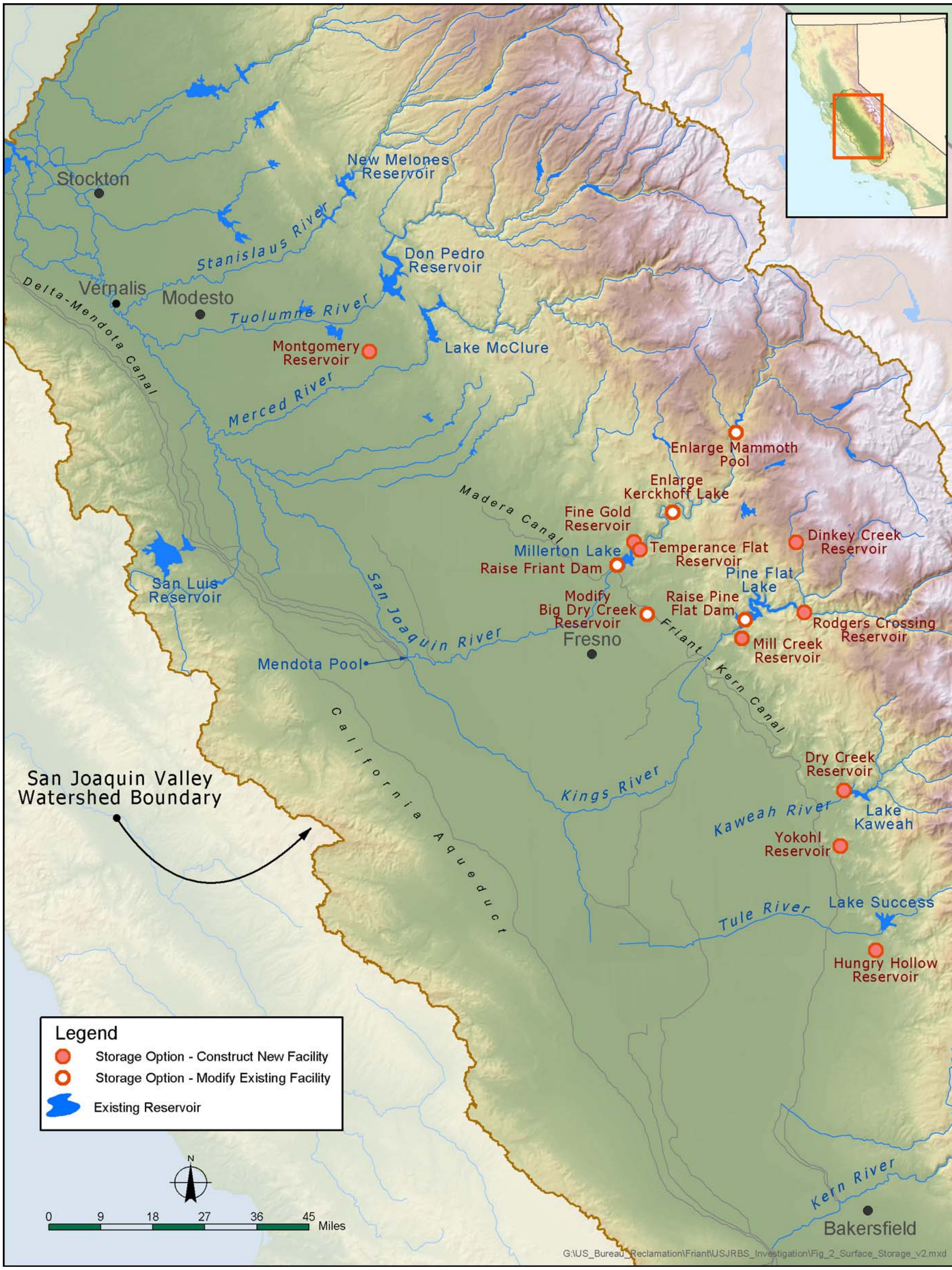

FIGURE 5-1. SURFACE STORAGE OPTION LOCATIONS

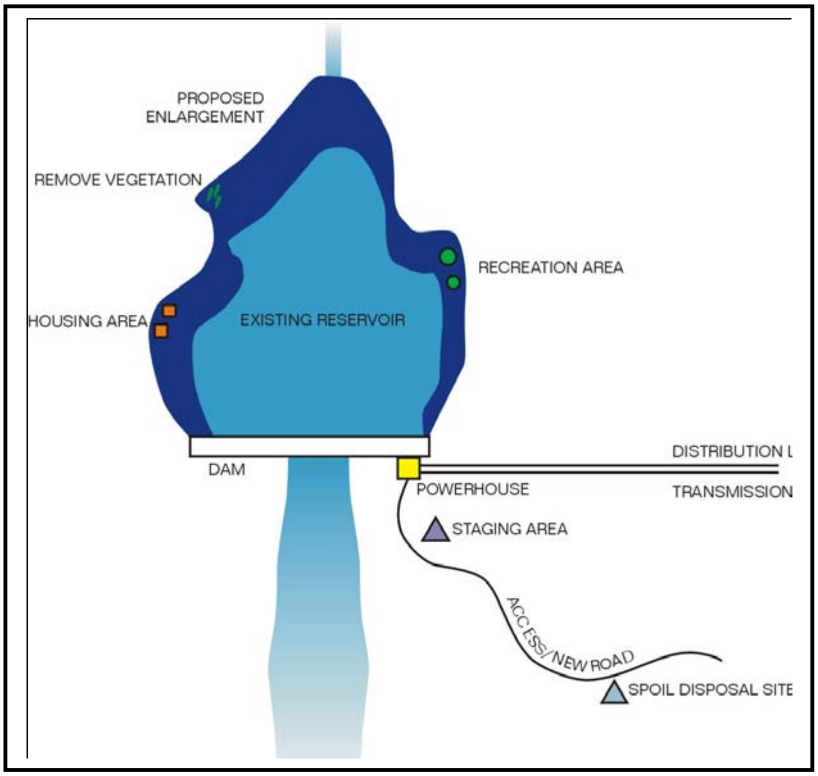

FIGURE 5-2. FEATURES CONSIDERED FOR RESERVOIR ENLARGEMENT

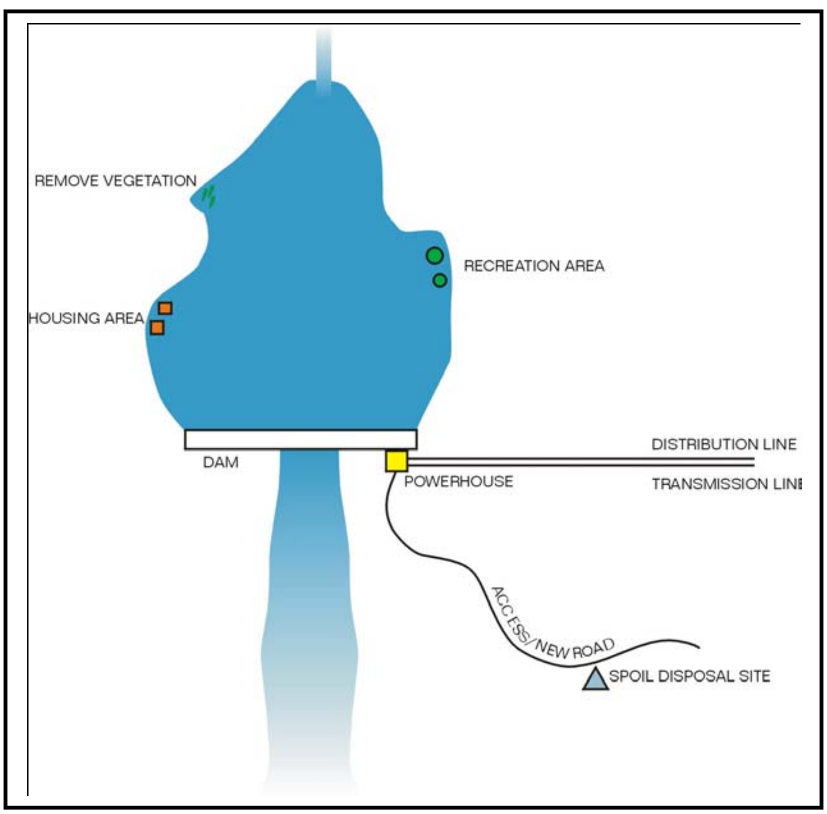

FIGURE 5-3. FEATURES CONSIDERED FOR NEW RESERVOIR

Merced River Watershed - Montgomery Dam and Reservoir

Description of Option

The potential Montgomery Reservoir site is located in Merced County, approximately 3½ miles north of the town of Snelling and 17 miles north of Merced. The reservoir would be created by a dam on Dry Creek, a northern tributary to the Merced River, downstream of New Exchequer Dam and Lake McClure. A zoned earthfill embankment would be constructed, 101 feet in height above the existing streambed. In addition to the main dam, the reservoir would require construction of eight saddle dams, with a combined crest length of 14,300 feet. At a pool elevation of 325 feet above mean sea level (MSL), the reservoir would store up to 241,000 acre-feet of water (see Figure 5-4).

The reservoir would store Merced River water released from Lake McClure, diverted at Merced Falls, and conveyed by gravity via the North Side Canal, an existing gravity distribution canal that serves the portion of the Merced Irrigation District (MID) lying north of the Merced River. Conveyance of water to and from Montgomery Reservoir would require conversion of the North Side Canal from a one-way to a two-way canal and a capacity increase to 2,000 cfs for a length of 30,000 feet.

Surplus flows from the Merced River stored in Montgomery Reservoir would be used to meet local water needs, allowing water stored in Lake McClure to be used for other uses. A pumping plant at the base of the dam and a new pipeline would discharge the water to the North Side Canal. Some of the stored water would flow west by gravity to MID water users served by the downstream portion of the North Side Canal. Additional water could be pumped upstream through the modified North Side Canal to serve MID customers located to the east between Montgomery Reservoir and the Merced Falls Diversion Dam. Water could also be transferred from the North Side Canal to the Main Canal of MID through a connecting pipeline, which would include a siphon beneath the Merced River.

Engineering and Environmental Findings

No major issues were identified regarding the technical feasibility of designing and constructing the required facilities. Most of the land that would be inundated is used for grazing, with sparse rural development. Adverse impacts to wildlife, recreational resources, and existing land uses are expected to be low. Impacts to botanical resources are expected to be more serious, but are likely mitigable. Further study would be required to obtain a reasonable assessment of the expected impacts to aquatic resources and water quality.

MID, the agency that would distribute the stored water under this proposal, has expressed concern regarding the quality of the water that would be developed. With a storage capacity of slightly more than 240 TAF and a reservoir surface area of nearly 8,000 acres, the average reservoir depth would be roughly 30 feet when filled. Concerns about high water temperature, the likelihood of algal growth, and relatively high evaporative losses make the water that would be developed undesirable to MID and its customers. This option will be dropped from further consideration.

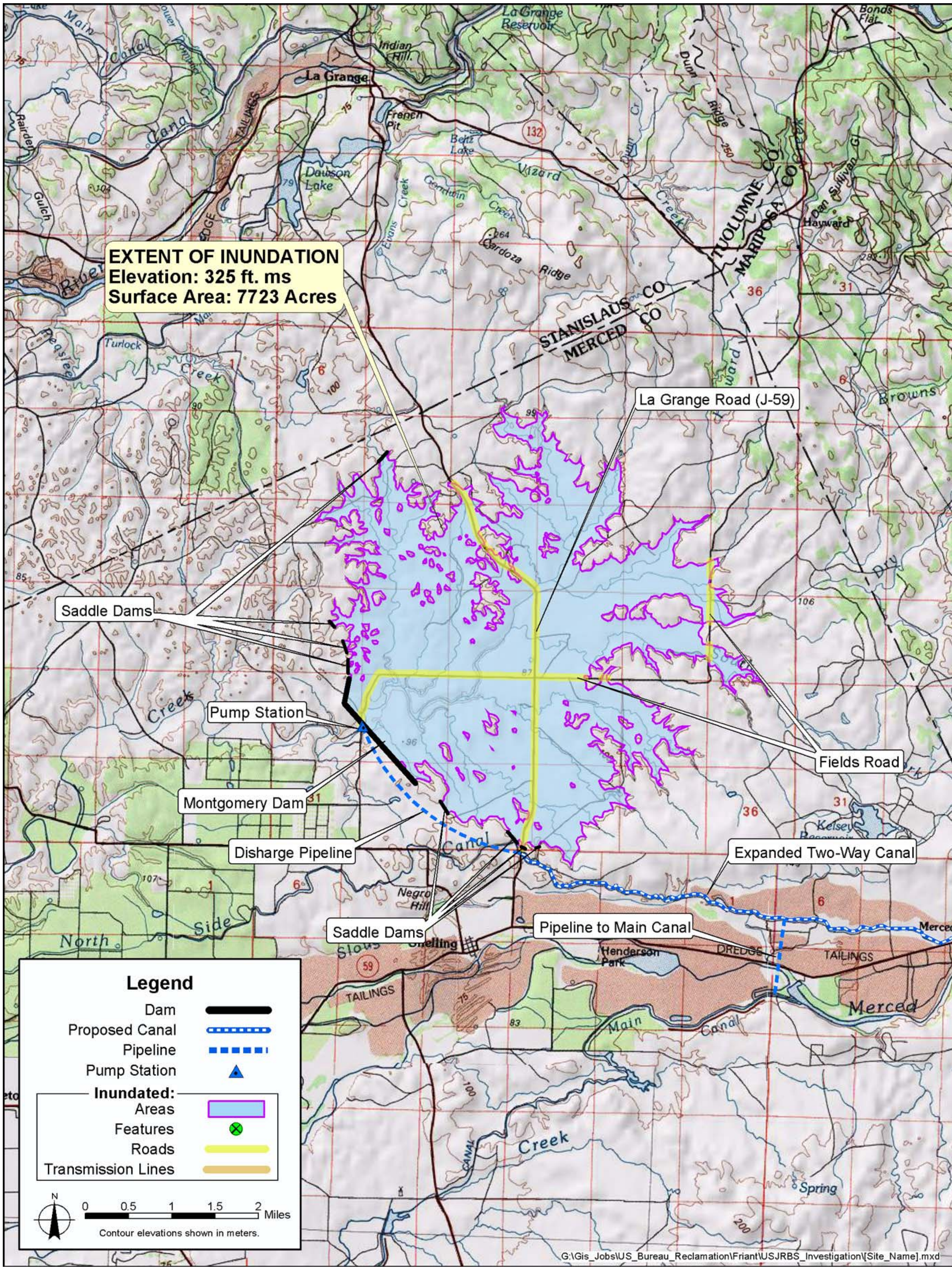

FIGURE 5-4. MONTGOMERY RESERVOIR OPTION

San Joaquin River Watershed – Raise Friant Dam

Description of Options

Friant Dam is a 319-foot high concrete gravity dam on the San Joaquin River about 20-miles northeast of Fresno. Potential modifications previously considered include 25-, 60- or 140-foot raises to increase storage capacity of Millerton Lake. Figure 5-5 illustrates the extent of enlarged Millerton Lake corresponding to the 140-foot raise option.

A 25-foot raise would increase the storage capacity by 132,000 acre-feet. This option would involve raising the dam crest and modifying the spillway and spillway chute. It would also require construction of a dike, approximately 3,000 feet long, across a low ridge saddle at the southwest margin of the existing reservoir. A 60-foot raise, which would increase storage capacity by 340,000 acre-feet, would also entail raising the dam crest and modifying the spillway and spillway chute. Approximately 8,500 feet of new dike would be required for a 60-foot raise. A 140-foot raise, which would result in approximately 870,000 acre-feet of additional storage capacity, would require new dikes of approximately 9,500 feet in total length.

An enlarged Friant Dam and Millerton Lake would continue to capture flow on the San Joaquin River. Additional storage capacity would provide opportunities to store larger flood volumes than the current reservoir. Stored water would continue to be diverted to the Friant-Kern Canal, the Madera Canal, and/or released to the San Joaquin River.

Engineering and Environmental Findings

As proposed, a dam raise would be accomplished with an overlay of roller compacted concrete on the downstream face of the dam. The saddle dam / dike on the southwest rim of the reservoir (i.e. left side, looking downstream) would be constructed with earthfill. For the largest dam raise considered, the dike would be well over 100 feet high in some locations. Safety considerations would be paramount in design of the dike. The availability of materials from local sources does not appear to be a limiting factor.

Millerton Lake Recreation Area facilities, along the left (south) side of the reservoir, include a boat ramp, marina, camping and day use facilities, and other structures. Most private residences near the reservoir lie at or above elevation 610 feet MSL, or greater than 25 feet above the current maximum reservoir level of 578 ft MSL.

American shad (*Alosa sappdissima*), an anadromous Atlantic Ocean fish successfully introduced to Sacramento and San Joaquin rivers and accidentally planted in Millerton Lake in the mid 1950s, is the only known landlocked population of the species. Spawning habitat in the upper portion of Millerton Lake and upstream in the San Joaquin River would be affected due to an enlargement of Millerton Lake. Other impacts to habitat and wildlife would vary relative to the extent of inundation. Any raise of Millerton Lake would affect recreation facilities on the current shoreline. Raise options greater than 25 feet would also affect residential areas and upstream power generating facilities. A 60-foot or 140-foot raise would inundate the abandoned Sullivan mine. Impacts to existing land uses, structures, and facilities appear mitigable, but mitigation would likely require significant cost. This option will be retained for further consideration.

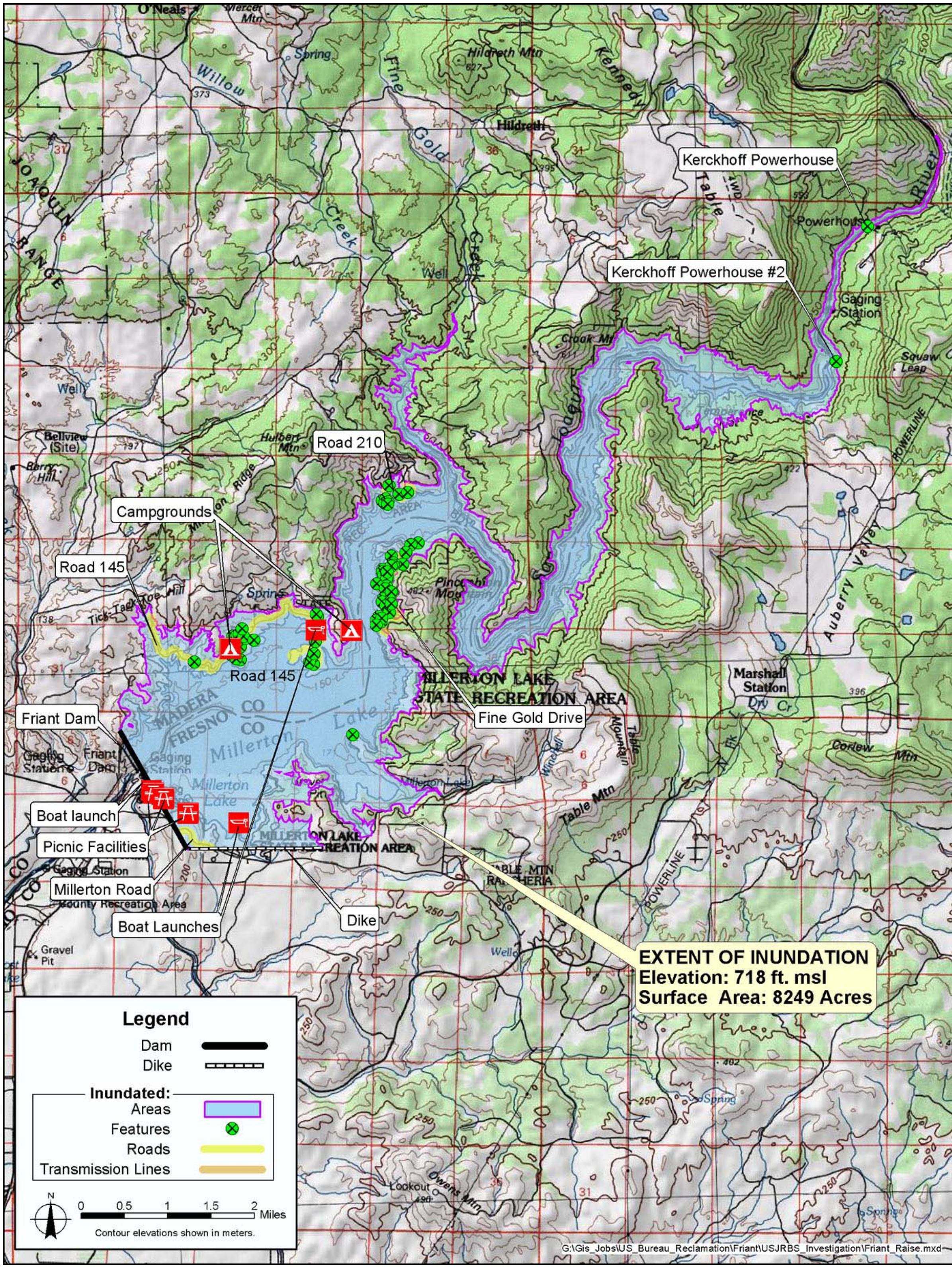

FIGURE 5-5. RAISE FRIANT DAM OPTION

San Joaquin River Watershed - Fine Gold Dam and Reservoir

Description of Options

Fine Gold Creek is a tributary to the San Joaquin River that enters Millerton Lake from the north. The creek drains a watershed area of approximately 91 square miles (see Figure 5-6). Two potential dam heights were considered, 380 feet (dam crest elevation 900 feet) and 580 feet (dam crest elevation 1,100 feet), which correspond to total storage capacity of 132,000 and 780,000 acre-feet, respectively. For each dam size, two potential dam types could be constructed: a roller-compacted concrete gravity structure or a concrete-face rockfill dam. The higher dam option would require construction of a saddle dam on the right (west) rim of the reservoir, approximately 100 feet high and 3,200 feet long.

In all Fine Gold Creek Reservoir options, the primary water source would be the San Joaquin River. The new reservoir would function as a pumped storage facility, with water pumped up from Millerton Lake for later release and recapture of hydroelectric energy. Natural runoff from Fine Gold Creek would supplement the Millerton supply.The stored water would be released to Millerton Lake and then diverted to the Friant-Kern or Madera Canal and/or released to the San Joaquin River. Pumping water from Millerton Lake to Fine Gold Creek Reservoir would provide an opportunity to increase available flood storage space in Millerton Lake, which would then be able to capture a larger portion of flood flows than it does currently.

Engineering and Environmental Findings

Geologic conditions appear suitable for dam construction at this site. Raw materials could be obtained from within the proposed reservoir inundation area. During construction, a temporary coffer dam approximately 80 feet high would be required above the permanent dam site on Fine Gold Creek to divert flows, and a second coffer dam approximately 60 feet high would be required to keep water from Millerton Lake out of the construction zone. One or more diversion tunnel would be required. The number and placement of tunnels depends upon the dam type selected.

Creation of Fine Gold Creek Reservoir would be expected to cause adverse environmental impacts. Extensive pine and oak woodland habitat would be affected, as would pockets of riparian and wetland habitats. Vernal pools and special status species of plants, terrestrial wildlife, and fish may be present in the inundation area. Western pond turtles live in Fine Gold Creek. Abandoned mines and mine tailings in the inundation area create the potential for water quality impacts. Pumped storage operations could affect water temperatures in Millerton Lake and cause fluctuations in water levels in both Millerton Lake and the new Fine Gold Creek reservoir. Lake level fluctuations would affect several species of fish, and could harm the spawning of largemouth bass.

No technical issues were identified that would physically prevent a dam from being constructed on Fine Gold Creek. However, further research would be required to more fully define the extent of resulting environmental impacts and how adverse environmental impacts could be mitigated. This option will be retained for further consideration.

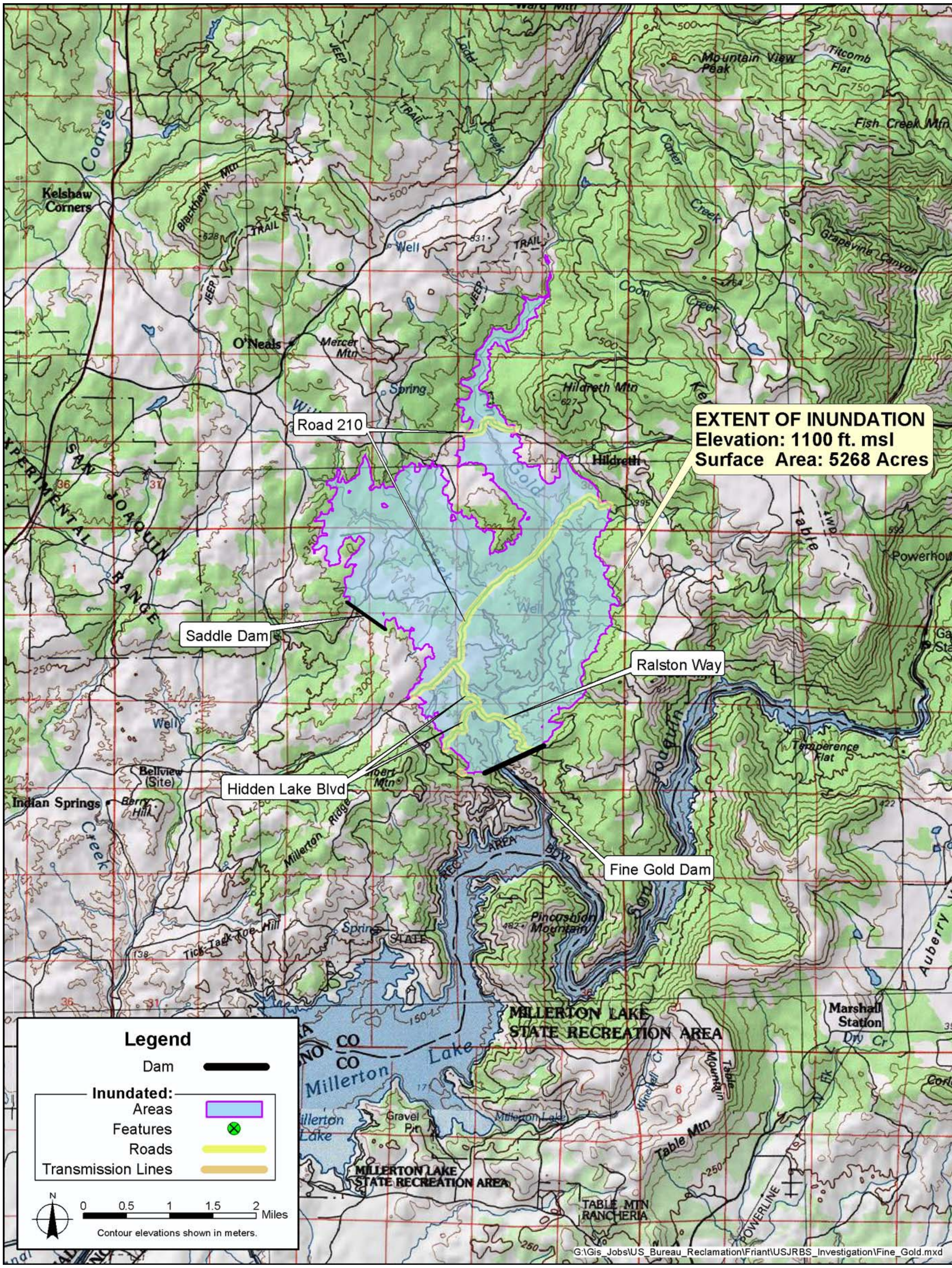

FIGURE 5-6. FINE GOLD CREEK RESERVOIR OPTION

San Joaquin River Watershed - Temperance Flat Reservoir

Description of Options

Temperance Flat is a wide, bowl-shaped area in the upper portion of Millerton Lake upstream of the confluence with Fine Gold Creek (Figure 5-7). Three dam sites with similar geologic conditions were considered that would result in the inundation of the Temperance Flat area; at River Mile (RM) 274, at River RM 279, and at RM 280. At each site, two dam sizes were considered, at crest elevations of 900 feet elevation (MSL) and 1100 feet. Two dam types were considered for each site - a roller-compacted concrete gravity structure and a concrete-face rockfill dam - each suitable for either the smaller or larger dam size.

Temperance Flat Reservoir would capture the flow of the San Joaquin River before it enters Millerton Lake. The operation of Temperance Flat Reservoir would be integrated with storage in Millerton Lake. Water would be released from Temperance Flat to Millerton Lake and diverted to the Friant-Kern Canal, the Madera Canal, and/or released to the San Joaquin River.

Engineering and Environmental Findings

Geologic conditions are favorable for dam construction at the sites considered and borrow sources for material could be obtained within the reservoir inundation area. Table 5-1 compares construction-related characteristics of the three potential dam site locations. As indicated, the depth of water in Millerton Lake at this location exceeds 200 feet, which would require larger cofferdams than the other sites considered, and access would be through a residential area. For these reasons, the RM 280 site was dropped from further consideration.

The RM 279 site and the RM 280 sites could both be accessed through the same route, which could be developed without creating impacts to the local community. Both sites would use the same general construction lay-down and staging areas within the reservoir pool. The RM 280 site would require the smallest size cofferdams of the three sites. However, the required length of the permanent dam crest would be greatest and it would result in the least potential storage volume. In consideration of these factors, the RM 280 site was dropped and the RM 279 site was retained for further consideration.

TABLE 5-1
TEMPERANCE FLAT DAM SITE OPTIONS

Item	RM 274	RM 279	RM 280
Volume (TAF)	**2,110**	**1,235**	**1,044**
Area (acres)	**8,200**	**5,500**	**4,800**
Water depth (ft)	**210**	**120**	**90**
Dam crest length (ft)	**3,200**	**3,500**	**4,000**
Access	**Residential**	**No Concern**	**No Concern**
Note: All estimates based on 1,100 feet MSL dam crest elevation.			

Maintaining Millerton Lake operations during construction would require diversion tunnels through both abutments of the new dam. The diversion tunnels would be 30 and 40 feet in diameter. A new reservoir at Temperance Flat would inundate existing hydroelectric generation facilities but would also create an energy production opportunity. The smaller dam option (inundation to 900 feet elevation) would inundate Kerckhoff Powerhouses 1 and 2. The larger dam option (inundation to 1,100 feet elevation) would also inundate Kerckhoff Dam and Reservoir and Wishon Powerhouse.

Either reservoir option at RM 279 would inundate much of the Millerton Lake State Recreation Area as well as the Squaw Leap Management Area, which is managed by the U.S. Bureau of Land Management. The larger reservoir option would also inundate Sierra National Forest lands above Kerckhoff Dam. The Patterson Bend whitewater boating run, below Kerckhoff Dam, would be partially inundated by a new Temperance Flat reservoir. It is considered a Class V rapid. A portion of the Horshoe Bend run, above Kerckhoff Reservoir would be inundated by the larger reservoir option. In addition, the larger reservoir option would inundate recreational facilities at Kerckhoff Reservoir.

In general, habitat types that would be affected by creation of Temperance Flat Reservoir are similar to those at Millerton Lake and Fine Gold Creek. The region is dominated by foothill woodlands of pine and blue oak, with open perennial grasslands. A considerable amount of such habitat would be inundated by a reservoir. Sixteen wildlife species of special concern are documented as occurring in the project area and could be affected by a new Temperance Flat reservoir.

Both American shad (Alosa sappdissima) and striped bass (Morone saxatilits) spawn in the reach of the San Joaquin River between Millerton Lake and Kerckhoff Dam. The American shad, an anadromous Atlantic Ocean species successfully introduced to Sacramento and San Joaquin rivers, was planted in Millerton Lake accidentally in the mid 1950s and is now the only known existing landlocked population of the species. Stocking of striped bass was suspended in 1987, but some natural reproduction occurs. The smaller Temperance Flat reservoir would likely result in adversely effects to spawning of both fish populations, and the larger reservoir would completely inundate that stretch of the river.

Prehistoric archaeological sites exist within the potentially inundated area, as do sites where mining occurred historically. Past mining sites would need to be assessed not only for their potential historic significance but also for their potential to affect water quality.

From a geologic and engineering perspective, the RM 279 site appears suitable for development of a storage facility. Further evaluation will is needed to more fully identify the extent of environmental impacts and mitigation requirements. This option will be retained for further consideration

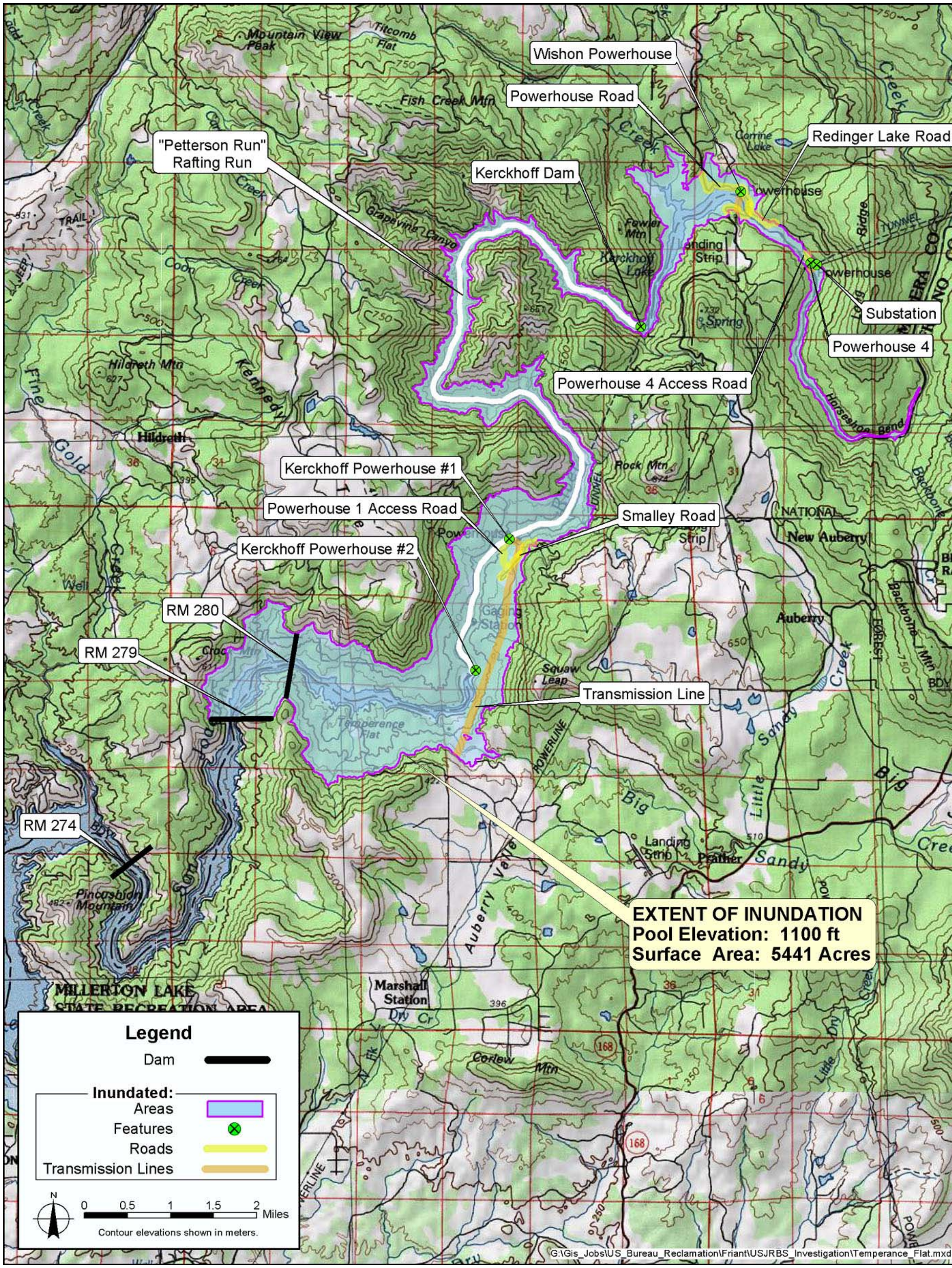

FIGURE 5-7. TEMPERANCE FLAT RESERVOIR OPTION

San Joaquin River Watershed - Kerckhoff Lake Enlargement

Description of Options

Kerckhoff Dam and Lake are components of the Pacific Gas and Electric (PG&E) Kerchkoff Project, which is located on the San Joaquin River, upstream of Millerton Lake, below the confluence of Willow CreekKerchkoff Lake, and serves as a afterbay to the Wishon Powerhouse and a forebay for diversion to Kerchkoff Powerhouses #1 and #2. Enlargement of Kerckhoff Lake would involve the construction of a new dam at a location downstream of Kerchkoff Dam. During the evaluation of Temperance Flat sites, the engineering and geology team identified a potential dam site at approximately River Mile 286 (RM 286) on the San Joaquin River, between Temperance Flat and the existing Kerckhoff Dam (Figure 5-8). The additional storage spacewould capture San Joaquin River flows and would be operated in coordination with Millerton Lake.

Engineering and Environmental Findings

As stated above, the potential dam site at RM 286 was identified after field studies for this Investigation had already been completed, thus, the engineering and environmental analysis for this option is less detailed than for other options. Potential dam sizes could range from 180 feet high, which would result in a dam crest elevation of 900 feet (MSL) and a capacity of 14,000 acre-feet, to a 680-foot high structure with crest elevation 1,400 feet and capacity of 2 million acre-feet.

The RM 286 site is narrower and steeper than the Temperance Flat sites considered further downstream, and would require smaller structures at potentially lower cost. The site is located above the upper limit of Millerton Lake and would not require cofferdams as large as those for downstream sites. It is possible that the existing Kerckhoff Dam and penstock could be incorporated in the design of the upstream cofferdam and diversion facilities. Impoundments at this site to el. 1,100 would inundate the same upstream areas as the larger Temperance Flat storage option (640 feet high dam at RM 279). Existing infrastructure that would be affected include Kerckhoff Dam and Reservoir, power plants, a bridge, and facilities around the Kerchkoff Lake shoreline. Environmental impacts would be similar to those described for Temperance Flat, although the portion of the San Joaquin River below the dam site would not be affected.

Impoundment up to el. 1,400 would inundate Redinger Dam and Lake and the entire Horshoe Bend whitewater run. Impoundment above el. 1,400 would impact the Chanwanakee community, which is on the southern shore of Redinger Lake.

The RM 286 site is similar to the RM 279 site and does not appear to present engineering or environmental concerns at this time that would preclude project development. This option will be retained for further consideration.

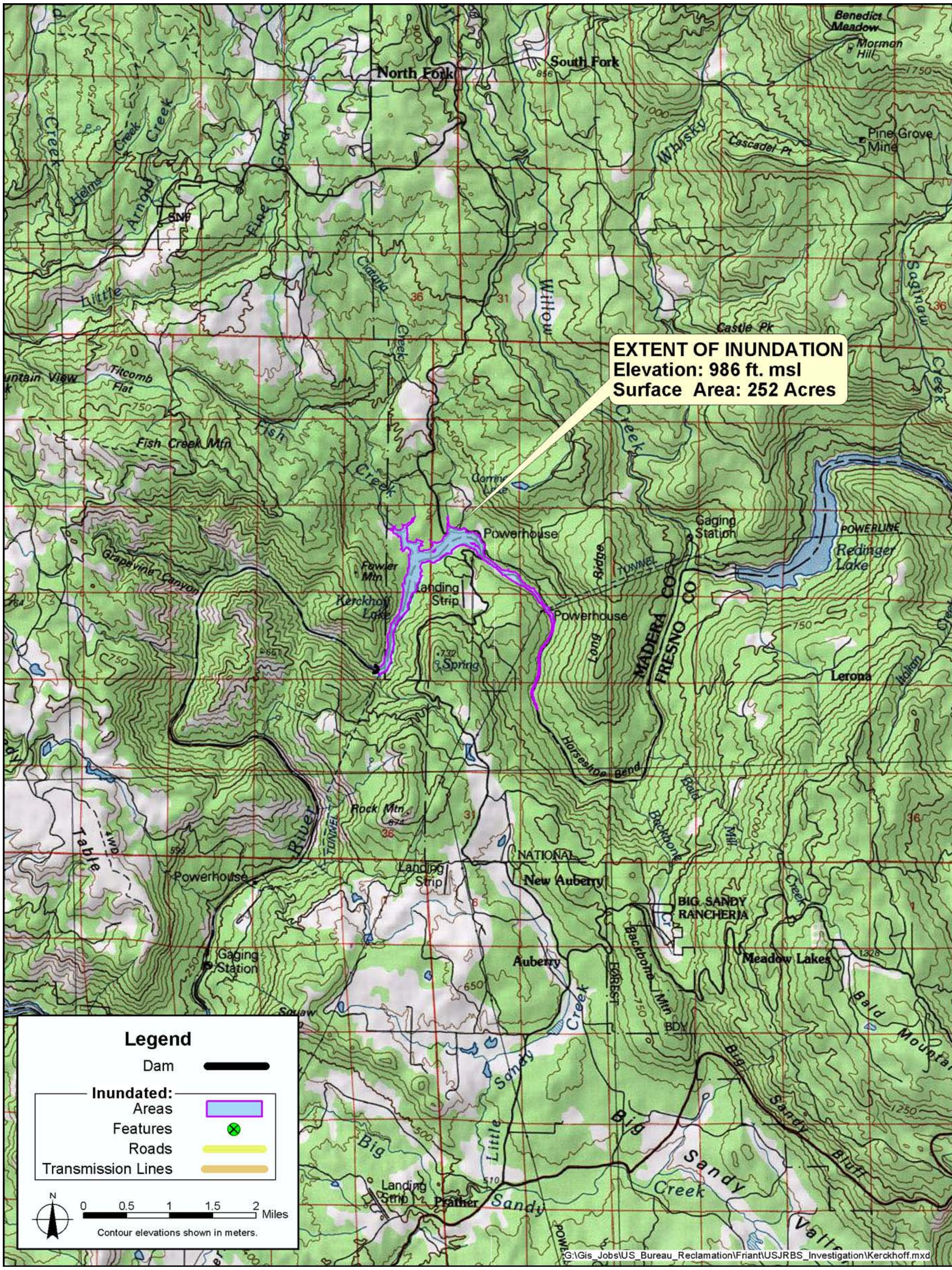

FIGURE 5-8. KERCKHOFF LAKE ENLARGEMENT OPTION

San Joaquin River Watershed - Mammoth Pool Reservoir Enlargement

Description of Options

Mammoth Pool Reservoir is owned and operated by Southern California Edison (SCE) as part of the Big Creek Project. Mammoth Pool Dam and Reservoir are located in the upper San Joaquin River watershed at the confluence of Chiquito Creek and the San Joaquin River, upstream of Kerckhoff Lake (Figure 5-9). The existing spillway is ungated.

In 1982 SCE completed a conceptual study on adding gates to the spillway to increase power generation. Storage volume could be expanded by about 30,000 acre-feet by installing 5 twenty-five-foot high radial gates on the spillway to raise the normal operating pool and increase active storage. To maintain dam freeboard, a 5-foot parapet wall would extend above the existing dam crest. This would increase the totoal capacity of Mammoth Pool by about 30 percent.

The enlarged reservoir would continue to capture San Joaquin River flows. Water could be released from an enlarged Mammoth Pool to the San Joaquin River and re-captured in Millerton Lake. Additional storage in Mammoth Pool would provide an opportunity to increase available flood storage space on the San Joaquin River. In addition, by increasing the water surface elevation the energy head would be increased, which would lead to increased hydroelectric energy production.

Engineering and Environmental Findings

The FWUA, in coordination with SCE, is currently re-evaluating an enlargement Mammoth Pool for water supply and power generation purposes. The modifications would be similar to those described above. On the basis of the previous study, no major engineering issues are expected that would physically prevent construction of gates over the spillway.

Institutional issues would need to be addressed to move the proposal forward. SCE, as owner of Mammoth Pool, would need to support the enlargement. In addition, the project would require a permit from the California Department of Water Resources' (DWR) Division of Safety of Dams (DSOD), which is reported to have a preference for ungated spillways. One approach to address this concern would be keeping the gates open during the rainflood season. Mammoth Pool Dam and Reservoir is also licensed and regulated by the Federal Energy Regulatory Commission, Office of Energy Projects.

Expansion of the reservoir would cause the inundation of mixed Sierran forest habitat, which is dominated by conifers but also contains hardwood species such as oak. Some riparian and wetland habitat would also be lost, which would probably require mitigation. Environmental impacts are expected to be relatively low and mitigable. This option will be retained for further consideration.

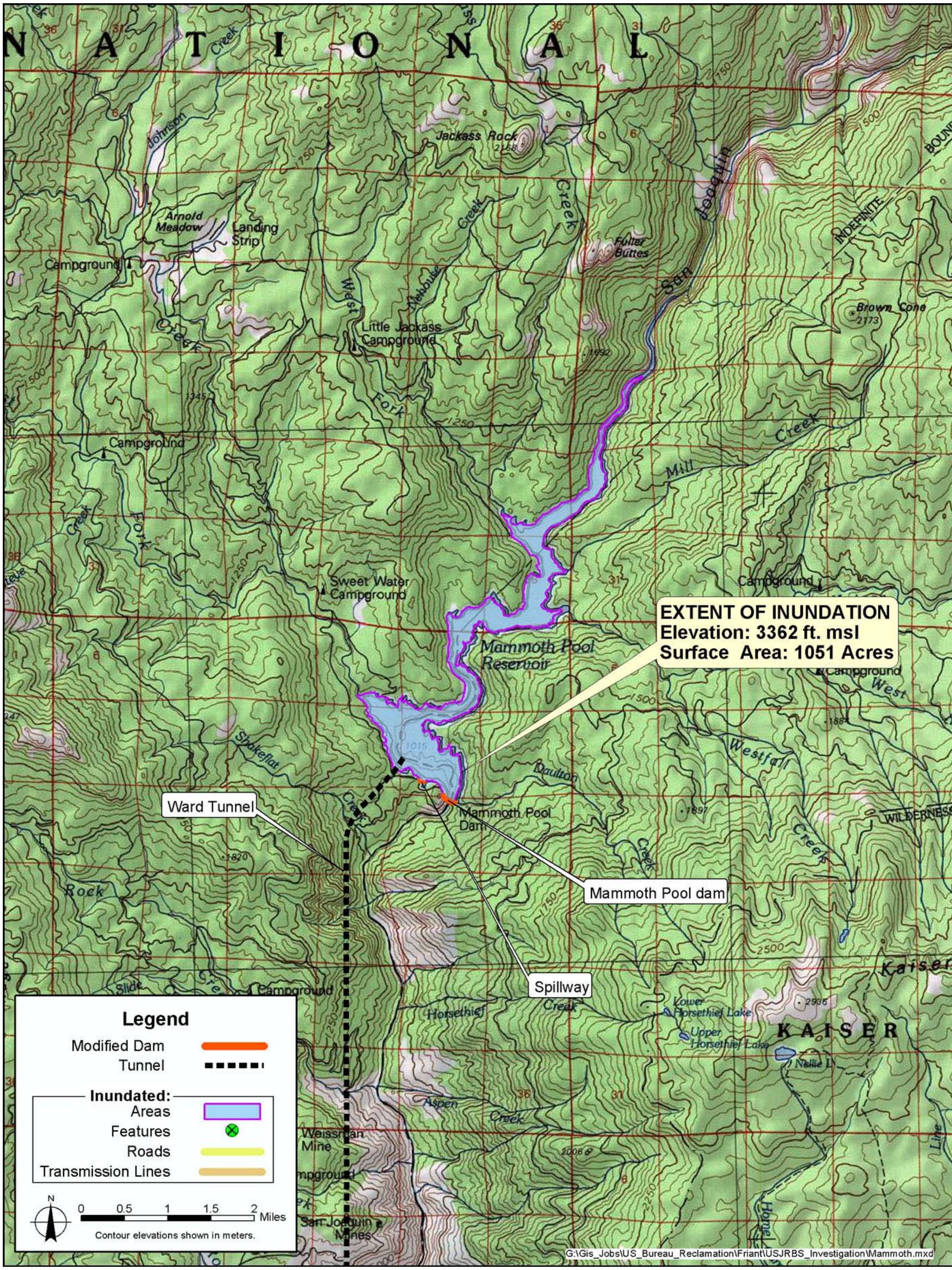

FIGURE 5-9. MAMMOTH POOL ENLARGEMENT OPTION

San Joaquin River Dry Creek Watershed - Big Dry Creek Dam and Reservoir

Description of Option

Big Dry Creek Dam and Reservoir is an existing flood control structure in Fresno County, near Clovis, operated by the Fresno Metropolitan Flood Control District (FMFCD) (Figure 5-10). The reservoir spans Dry Creek and associated smaller drainages to the north of Big Dry Creek. A zoned earthfill embankment, the dam creates a reservoir with a storage capacity of approximately 30,000 acre-feet. However, due to seepage concerns and lack of inflows, the total storage capacity has not been exploited.

Utilization of the full 30,000 acre-feet storage capacity at a minimum would require construction of a turnout from the nearby Friant-Kern Canal, northeast of the reservoir. The proposed turnout would be built at the point where the canal siphon passes under Big Dry Creek. In addition, construction of an energy dissipation structure would reduce velocities of the new flows conveyed into the reservoir.

Under this proposal, the new conveyance would enable the Big Dry Creek Reservoir to be operated as an off-stream storage facility for water diverted from the Friant-Kern Canal. The stored water would be used to supplement or offset the delivery to service areas along the Friant-Kern Canal. Due to the flood control obligation of the reservoir, no carryover storage would be allowed into the wet season.

Engineering and Environmental Findings

Dam safety concerns related to seepage make the viability of this option uncertain. The DWR Division of Safety of Dams (DSOD) has indicated that no more than 10,000 acre-feet can be stored in the existing reservoir, and only if the dam demonstrates satisfactory performance when the reservoir is filled to 25 percent of the dam height and again at the 50 percent level. The duration of storage is also restricted to at most 90 days, from April through September. The 25 percent level test was accomplished without significant seepage problems. The District is has not had adequate water to test the 50 percent requirement. Modification of the dam for water storage longer than 90 days may require extensive reconstruction of the dam.

Few environmental impacts would be expected from storing up to 30,000 acre-feet over periods longer than 90 days. Although some riparian habitat may be adversely affected, this option presents an opportunity to increase the total amount of riparian habitat. Vernal pools and some species of concern that are known to exist in the area but not known to occupy the specific site that would be inundated.

This option will be dropped from further consideration because of uncertainty regarding the ability to convert this facility for long-term storage capacity, and the relatively small storage amount. However, the site may be suitable for integration with groundwater recharge facility operations. The existing facility can divert up to 700 cfs of detained floodwater to the San Joaquin River through the Little Dry Creek Flood Channel. Releases up to 150 cfs can also be made to Big Dry Creek and distributed to downstream detention basins in the FMFCD system to assist in recharging the regional groundwater basin.

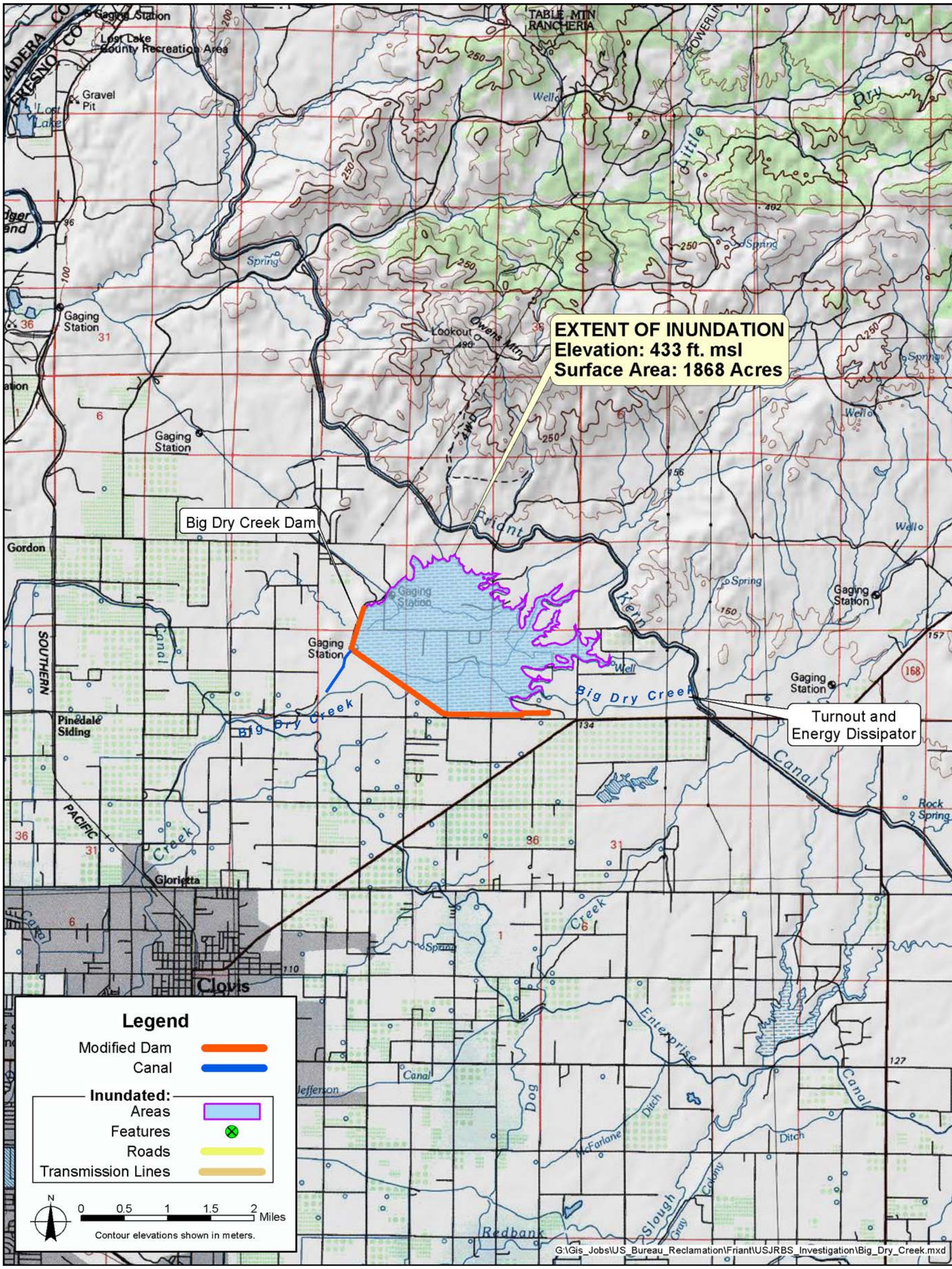

FIGURE 5-10. BIG DRY CREEK RESERVOIR OPTION

Kings River Watershed - Pine Flat Dam Raise

Description of Options

Pine Flat Dam and Reservoir are located in Fresno County, near the community of Piedra, about 30 miles east of Fresno. The dam is on the Kings River at RM 95, about 20 miles downstream of its confluence with the North Fork of the Kings River (Figure 5-11).

Pine Flat Dam, a concrete gravity structure completed by the COE in 1954, is 429 feet high, with a crest elevation of 916.5 feet (MSL). A 165 mW power plant operated by Kings River Conservation District (KRCD) is located at the downstream base of the dam on the right side. A PG&E power plant and penstock (Kings Power Plant) is located on the upper margin of Pine Flat Reservoir.

The proposed option involves increasing the gross pool elevation of the reservoir by 20 feet, resulting in 124,000 acre-feet of additional storage. This would be accomplished by raising the dam crest 12 feet and replacing the existing 42-foot wide by 36-foot high tainter (radial) gates with 59 foot high gates. Modifications to other features at the dam would also be required. This option would also require raising the PG&E Kings River Power Plant 21.5 feet and reconfiguration of the Pine Flat Power Plant at the toe of dam. Additional water stored in the enlarged Pine Flat Reservoir would be released to the Kings River to supplement CVP deliveries or to offset water released from Millerton Lake.

Engineering and Environmental Findings

Although engineering features for this option would be extensive, as described above, no technical constraints were identified that would limit their design or construction. However, potential environmental impacts of raising the gross pool of Pine Flat Reservoir by 20 feet would be considerable. In a 2001 report, the COE identified environmental impacts associated with a 15-foot raise. These include periodic inundation of up to 300 acres of riparian, oak woodland, oak savannah, and grassland habitat, and about 1.75 miles of the Kings River upstream of the reservoir for about 5 percent of the time between mid-May and late August each year. The enlarged reservoir would extend to a point just below the portion of the Kings River that is designated as a Special Management Area, within which no development is allowed without Congressional authorization.

Inundation of about one mile of rapids during the late spring and summer would adversely affect rafting and trout fishing uses. The raised reservoir would also partially or fully inundate several recreation facilities along the north shore of the reservoir and along the river just upstream of the reservoir gross pool limit. These facilities provide for day use, camping, boat launching, moorage, as well as a take out point and base camps for whitewater boating. Reservoir expansion would also inundate terminal points of tributary streams where foothill yellow-legged frogs and western pond turtles are likely. Valley elderberry longhorn beetles, a threatened species (Federal), are also present throughout the area.

The COE dropped this option from their flood control study on the basis of environmental issues. For the Investigation, this site will be retained for consideration of water supply opportunities on the San Joaquin River. The evaluation will consider using and enlarged Pine Flat Reservoir to support water exchanges between Millerton Lake and Pine Flat Reservoir water users.

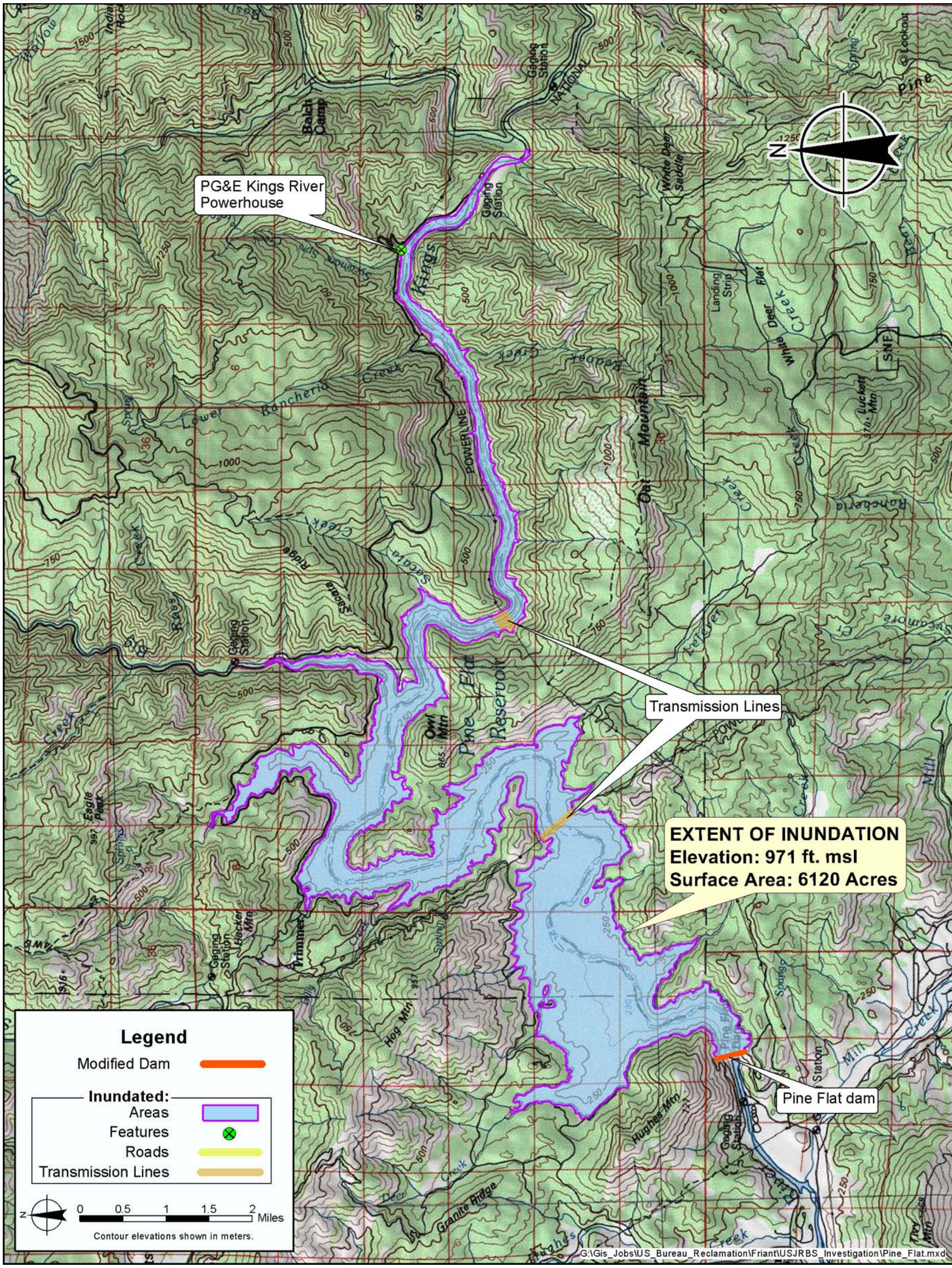

FIGURE 5-11. PINE FLAT RESERVOIR ENLARGEMENT OPTION

Kings River Watershed - Mill Creek Dam and Reservoir

Description of Options

Mill Creek flows into the Kings River approximately 1.7 miles downstream of Pine Flat Dam. A dam could be constructed on Mill Creek, approximately 1.3 miles upstream of the confluence that would impound a reservoir with a storage capacity of up to 200,000 acre-feet (Figure 5-12).

As previously considered by the Kings River Conservation District (KRCD) the new dam would consist of a zoned embankment structure up to 250 feet in height with a crest length of 3,700 feet at an elevation of 830 feet above mean sea level (MSL). Gross pool would be at elevation 800 feet msl. Flood flows in the Kings River would be diverted by gravity into Mill Creek Reservoir by means of a 5,000-foot long, 10-foot diameter, unlined conveyance tunnel. Stored water would be used to offset releases from Millerton Lake.

Engineering and Environmental Findings

No problematic issues are evident related to the physical capability to construct the proposed facilities. Foundation conditions include competent bedrock. Sufficient quantities of raw materials are nearby, the electrical grid is close, an existing road leads directly to the construction site, and a landing strip is within two miles. Staging area is more than adequate. Environmental concerns, however, are more extensive.

At maximum pool, the reservoir would inundate about 4.5 miles of Mill Creek. Mill Creek, a broad alluvial plain with a braided streambed, sustains a sycamore alluvial woodland (SAW), a sensitive habitat type that hosts a diverse assemblage of wildlife, particularly birds. An extensive SAW is located in the lower reaches of Mill Creek near its confluence with the Kings River (COE, 1994). Although sycamore trees are common, SAW has been described as a “very rare and essentially irreplaceable habitat type” (Carson, 1989). There are fewer than six viable occurrences and/or less than 2,000 acres in California and worldwide (Prose, 2002). Reservoir construction and water diversion are considered threats to SAW habitat, as sycamores have little tolerance to artificially manipulated water levels (Prose, 2002). Sexual regeneration of SAW depends upon substantial scour caused by flood events (Enstrom, 2002). Replacement of SAW is unlikely to be successful and its destruction is therefore unmitigable (Enstrom, 2002).

Fish species adapted to stream environments would also be negatively impacted, but fish suited to lake environments could benefit. The reservoir would provide excellent conditions for both cold-water and warm-water fisheries because its deep waters would likely stratify during the summer. The reservoir would inundate Wonder Valley Ranch, a 75-acre resort, conference center, and summer camp that provides a wide variety of recreational facilities. In addition to the ranch, several houses and ranchettes would be inundated.

In sum, site characteristics appear well suited to construction. However, because loss of SAW is considered unmitigable by resource agencies, this option will be dropped.

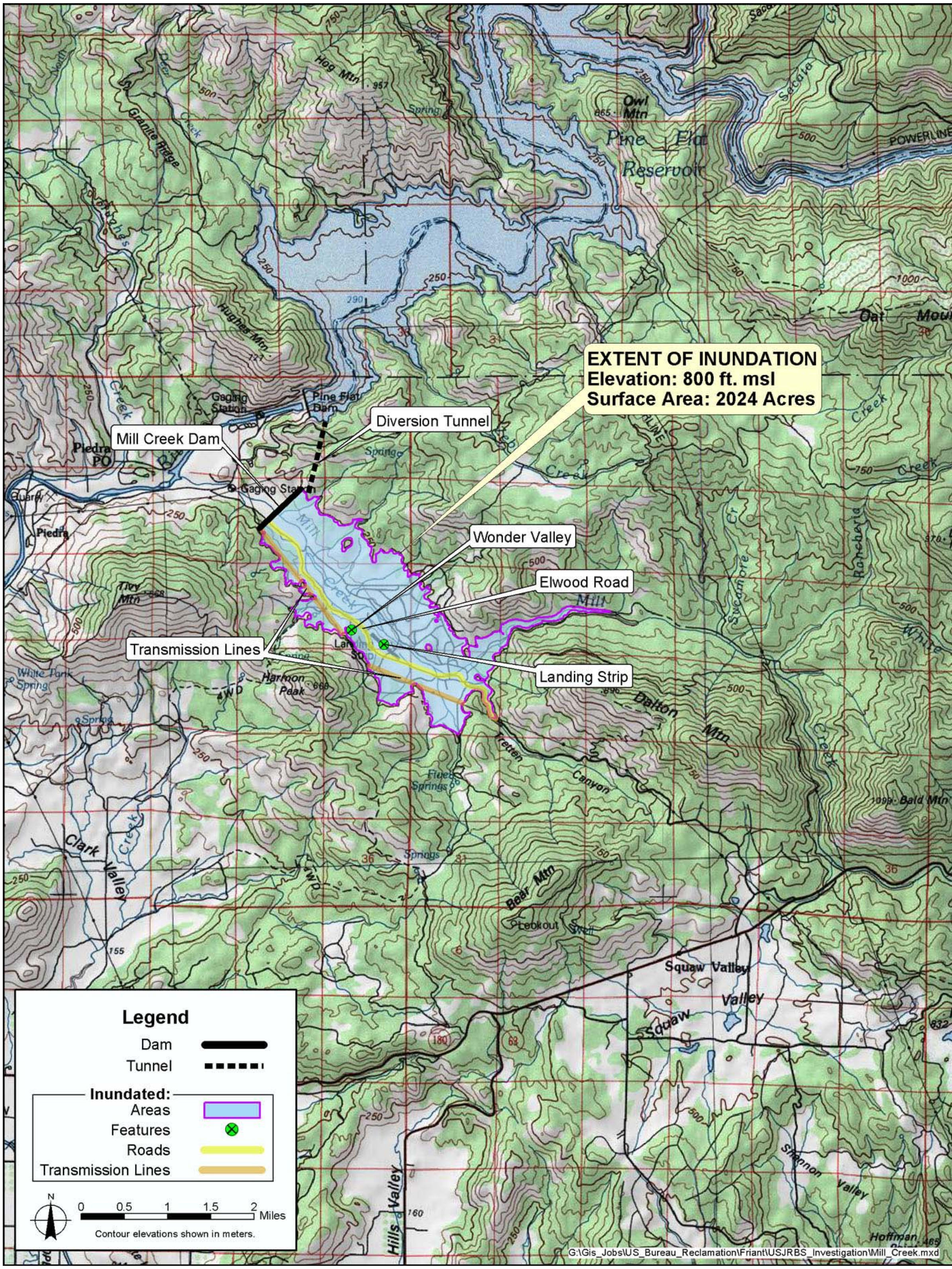

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FIGURE 5-12. MILL CREEK RESERVOIR OPTION

Kings River Watershed - Rodgers Crossing Dam and Reservoir

Description of Options

A potential dam at Rodgers Crossing would be located on the main stem of the Kings River at RM 116, approximately one half mile upstream of its confluence with the North Fork (Figure 5-13.). Two options have been studied previously; a roller-compacted concrete embankment dam up to 660 feet above streambed level that would create a reservoir up to 950,000 acre-feet, and a 400-foot high concrete arch dam that would create a reservoir up to 295,000 acre-feet. The larger dam would inundate about 10 miles of upstream river, and the smaller option would inundate about 8 miles of river. Stored water would be released to the Kings River to offset releases from Millerton Lake.

Engineering and Environmental Findings

The site appears to have suitable foundation conditions for construction of a dam. Raw material for a concrete dam is available – numerous outcrops of hard, resistant bedrock are evident within the vicinity of the damsite. All are potential quarry sites from which concrete aggregate could be obtained. PG&E owns electric power distribution facilities in the area, and staging areas are available where the canyon widens both upstream and downstream of the damsite.

The Kings River is one of the least disturbed large rivers in California and its wild trout population is considered one of the finest in the state. The California Department of Fish and Game designates the stretch between the upper limit of Pine Flat Reservoir to the confluence of the Middle and South Forks as a Wild Trout Fishery. From its confluence with Cabin Creek, about 9 1/5 miles above the proposed damsite, the Kings River is a federally designated Wild and Scenic River. The inundation area of the larger reservoir option would extend into the Wild and Scenic portion of the river. Both reservoir options would inundate portions of the Kings River Special Management Area. Inundation of either the Wild and Scenic reach or the Special Management Area would require Congressional approval.

Construction of a reservoir at Rodgers Crossing would be expected to cause unmitigable impacts to recreational resources in the area. Four U.S. Forest Service campgrounds are located along the river. Commercial and private white water rafting is conducted on the main stem of the Kings River above Pine Flat Reservoir.

Extensive riparian habitat would also be lost by creation of a Rodgers Crossing reservoir. This would pose a mitigation challenge simply because of the amount of habitat that would need to be restored or enhanced to compensate for the loss. Mill Flat Creek, a large tributary, joins Kings River about two miles upstream of the proposed dam site. This creek is an important spawning area for several native fishes in the Kings River, some of which are designated as State Species of Special Concern by the Department of Fish and Game. The new dam and reservoir would create barriers to fish migration.

This option will be dropped for several reasons. The extent of recreational impacts that would result from construction of Rodgers Crossing Reservoir may be unmitigable and the ability to mitigate fishery impacts appears low. An act of Congress would be required to permit inundation of the Kings River Special Management Area.

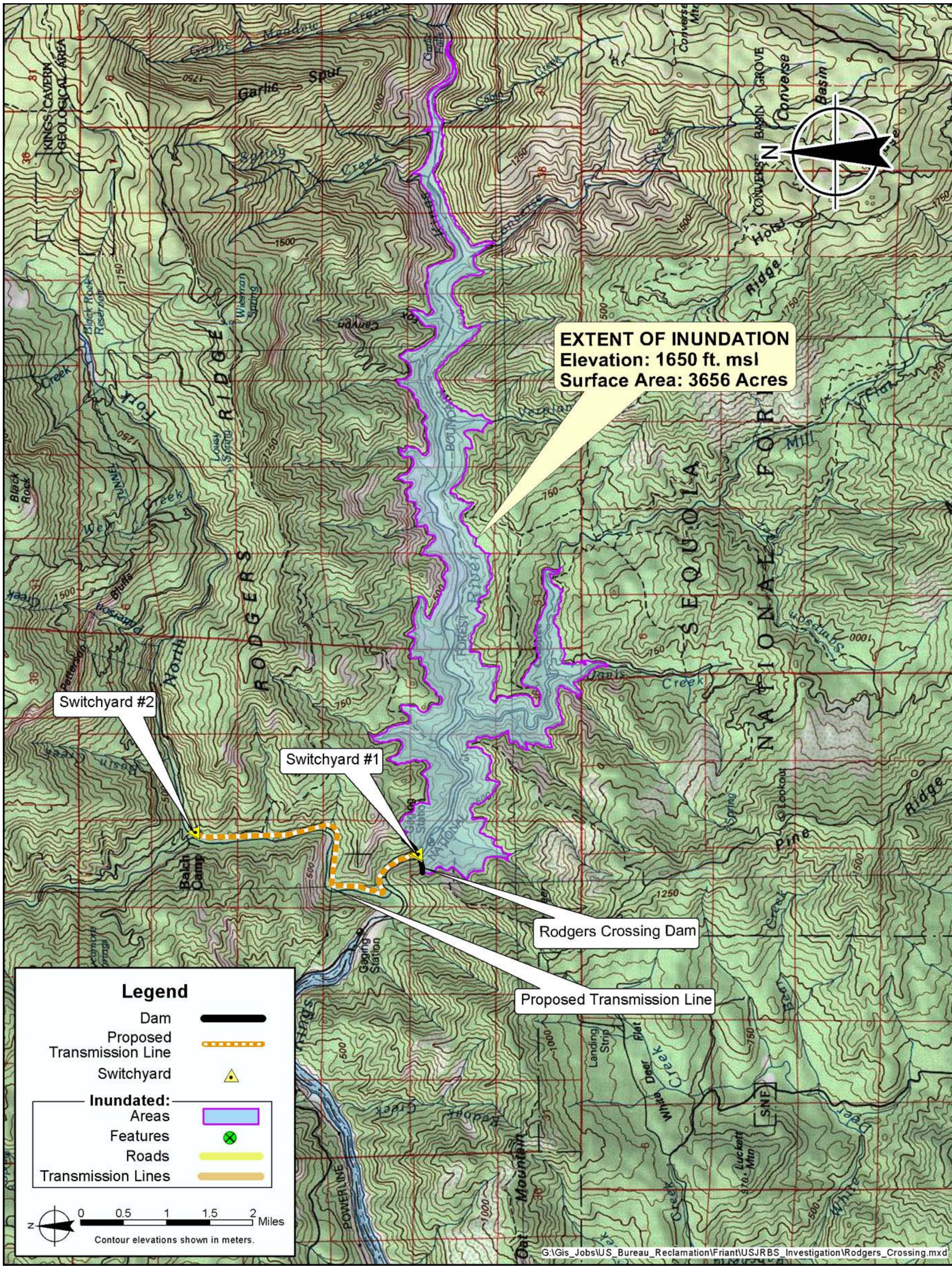

FIGURE 5-13. RODGERS CROSSING RESERVOIR OPTION

Kings River Watershed - Dinkey Creek Dam and Reservoir

Description of Options

Dinkey Creek is within the upper watershed of the North Fork of the Kings River. A dam at Dinkey Creek would be located within Sierra National Forest at an elevation of approximately 5,425 feet MSL. It would be constructed as a zoned rockfill dam, approximately 340 feet high and 1,600 feet long. Full reservoir capacity would be approximately 90,000 acre-feet (Figure 5-14). This option would include a 70-foot wide spillway on the right abutment with discharge bucket, two power plants, a second diversion dam, connecting tunnels, penstocks, and surge tanks. The diversion tunnels together would total 46,000 feet in length. The power plants would each consist of a single generating unit, 26,000 kW and 63,000 kW, respectively.

Water stored in a new reservoir at Dinkey Creek would be released to Dinkey Creek, which flows into the North Fork of the Kings River. Dinkey Creek discharges would offset releases from Millerton Lake to the San Joaquin River through exchange.

Engineering and Environmental Findings

Site conditions appear suitable for construction. The dam would be founded on hard granite. Pervious raw materials are available, though not quantified or tested. Although deposits of impervious materials containing a high percentage of fines were not noted in the vicinity of the dam site, they may be found in nearby meadow areas. Paved county roads are within one mile of the dam site and graded roads pass both the right and left abutments. A staging area could be situated 1.5 miles upstream of the proposed dam site, where the canyon widens.

Adverse environmental impacts would be expected in all categories assessed – botany, wildlife, aquatic biology and water quality, recreation, and land use. In particular, a reservoir at Dinkey Creek would fundamentally alter the existing recreation based community. There is potential for adverse impacts to fisheries and fishing-oriented recreation resources. A reduction in flow, particularly during spring and summer when rainbow trout are spawning and the young are growing, could affect physical habitat availability. Changes in water temperature below the dam could adversely impact trout and the dam would impede migration.

Although remote, Dinkey Creek is a popular recreation area and trout fishing destination. Several campgrounds and residences are located near the stream. The area that would be inundated includes two organization camps, recreation residences, paved and unpaved roads that provide access on both sides of the stream to recreational resources in the Sierra National Forest. Adverse regional land use impacts could also be expected. The community of Dinkey Creek and nearby resorts provides lodging and other recreation oriented services. The area surrounding the proposed inundation pool contains an organization camp, a public cabin complex, numerous recreation residences, developed campgrounds, picnic areas, trails, and parking areas. Inundation of roads and recreational resources they serve would adversely impact an entire established community and may be unmitigable. This option will be dropped from further consideration

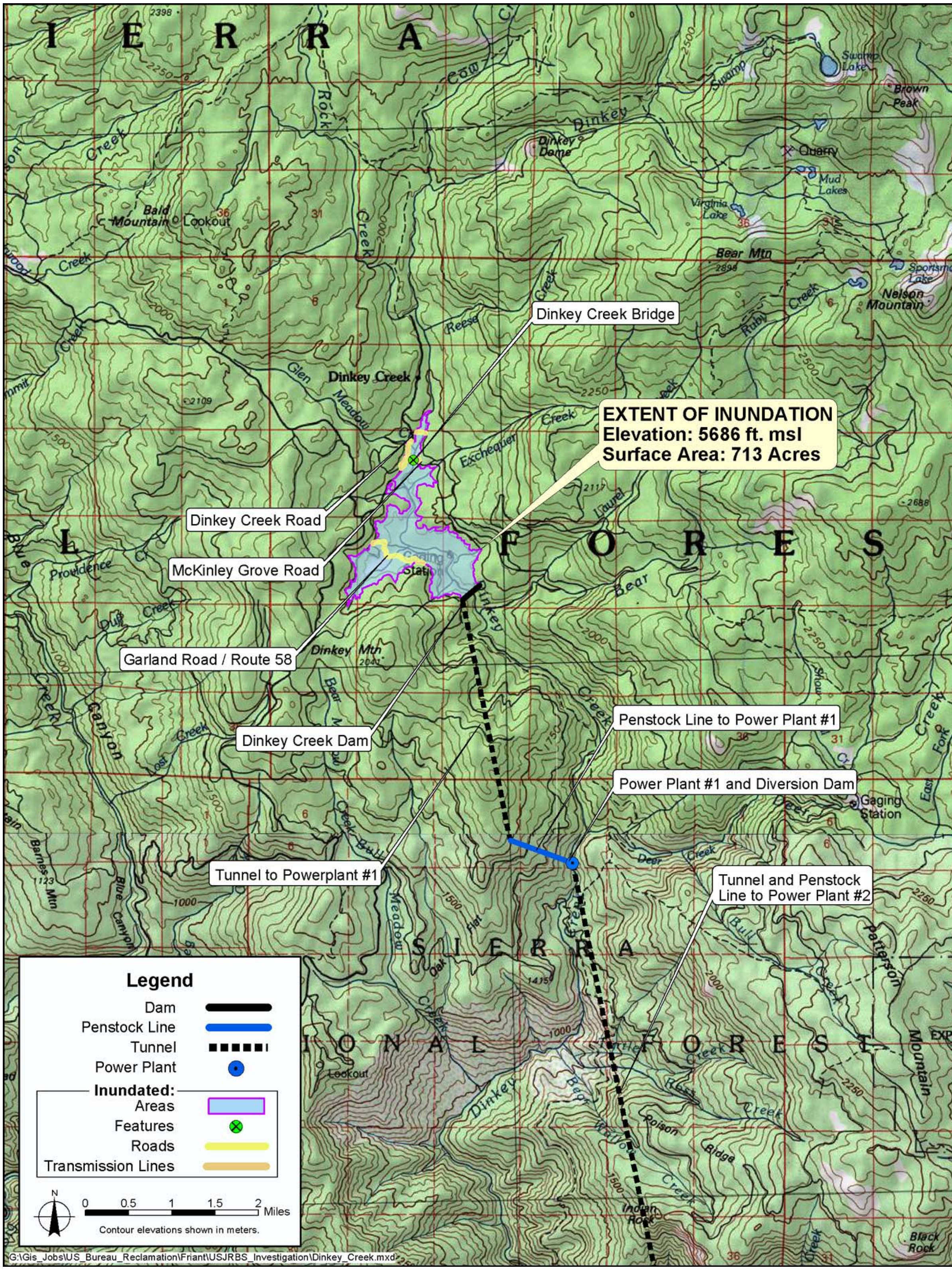

FIGURE 5-14. DINKEY CREEK RESERVOIR OPTION

Kaweah River Watershed - Dry Creek Dam and Reservoir

Description of Options

Dry Creek Dam and Reservoir would be a new facility on Dry Creek, which is a tributary to the Kaweah River just downstream and northwest of Terminus Dam. The dam site is in Tulare County, about 25 miles east and north of Visalia, north of the community of Lemoncove, and about 1¾ miles north of Dry Creek's confluence with the Kaweah River. The dam would be a 200-foot high roller-compacted concrete (RCC) structure with a crest length of approximately 3,210 feet, and would impound a reservoir with a storage capacity of up to 70,000 acre-feet (Figure 5-15).

Water would be diverted from Lake Kaweah through a 7,600-foot long gravity tunnel, 12 feet in diameter. The new reservoir would also capture natural runoff from Dry Creek. Stored water would be released to Dry Creek, flow down the Kaweah or St. Johns rivers to the Friant-Kern Canal, and used in lieu of deliveries from Millerton Lake through exchange. A like amount of Millerton Lake water could be released to the San Joaquin River.

Engineering and Environmental Findings

No serious issues related to construction requirements are evident. The dam and reservoir site is generally undeveloped with the exception a few rural residential properties. The dam site is underlain by competent hard rock, and sufficient sand and gravel would be available from a large nearby active quarry. A road provides direct access to the site, staging and lay down areas are located immediately upstream and downstream, and electrical power is available from the powerhouse at Terminus Dam or other nearby commercial sources.

Creation of the Dry Creek Reservoir would result in adverse impacts to botany resources. A sycamore alluvial woodland (SAW) exists near the confluence of Dry Creek and the Kaweah River. Although sycamore trees are common, SAW has been described as a "very rare and essentially irreplaceable habitat type" and the Dry Creek stand as one of the largest in the Central Valley (Carson, 1989). There are fewer than six viable occurrences and/or less than 2,000 acres in California and worldwide (Prose, 2002). Reservoir construction and water diversion are considered threats to SAW, as sycamores have little tolerance to artificially manipulated water levels (Prose, 2002). Sexual regeneration of SAW depends upon substantial scour caused by flood events (Enstrom, 2002). Successful replacement of SAW is considered unlikely and its destruction is therefore unmitigable (Enstrom, 2002).

Riparian habitat that may also host sensitive species such as willow flycatcher, foothill yellow-legged frog and western pond turtle. In addition, several special-status plant species are recorded around the Dry Creek area including a population of Kaweah brodiaea (Brodiaea insignis, state-listed as endangered) and a very large population of spiny-sepaled button-celery (Eryngium spinosepalum, California Native Plant Society List 1B). The principal effects on aquatic biological resources would result from replacement of a stream environment with lacustrine habitat. The most likely native fish species to be affected would be California roach, although its presence in Dry Creek is not known. In sum, no major conflicts with construction requirements are foreseen.

This option would result in adverse and potentially unmitigable impacts to SAW habitat. Therefore, it will be dropped from further consideration.

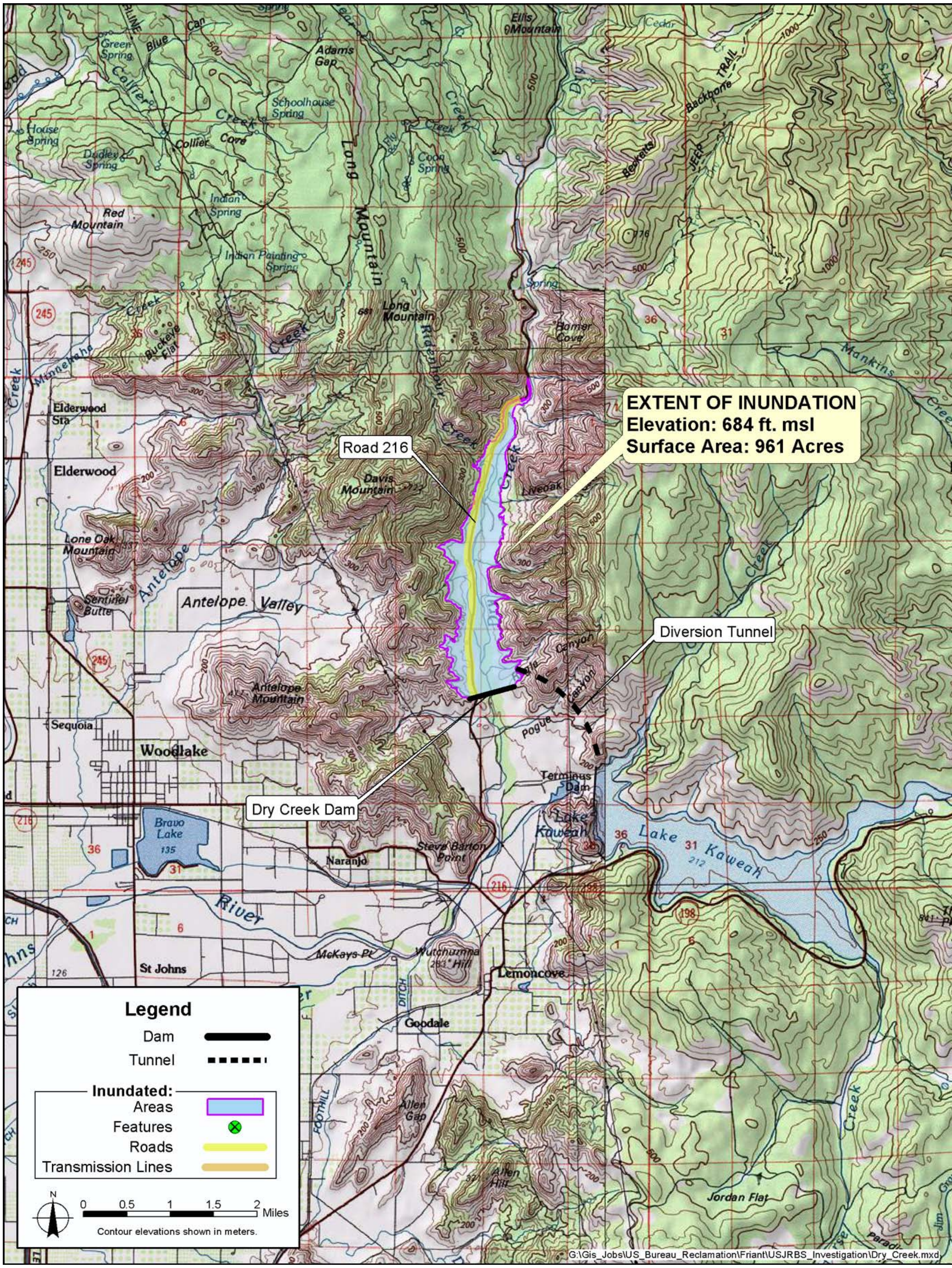

FIGURE 5-15. DRY CREEK RESERVOIR OPTION

Kaweah River Watershed - Yokohl Valley Dam and Reservoir

Description of Options

Yokohl Valley Dam would be constructed approximately 15 miles east of Visalia and 8 miles south of Lake Kaweah. A 260-foot high earthfill dam, with a crest length just under 3,000 feet, would create a 450,000 acre-feet. Two small saddle dams in the hills west of the main dam site would be required (Figure 5-16).

Two configurations have been previously studied, based on different sources of water. One option would be a pumped storage project that would divert water from the Friant-Kern Canal. This is a variation of an option that was described initially in a study of the Mid-Valley Canal by USBR. A second option would divert and pump water from Lake Kaweah during flood periods via an 8-mile long, 10-foot diameter tunnel. In both cases, supplementary flows would come from natural runoff in Yokohl Creek. Stored water would be released to Yokohl Creek and directed to the Friant-Kern Canal to supplement CVP deliveries or to offset releases from Millerton Lake to the San Joaquin River. Only the first option, off canal storage from the Friant-Kern Canal is considered in this Investigation.

Engineering and Environmental Findings

Site characteristics appear to pose no barriers to construction. Underlying rock conditions would be adequate for a dam foundation, sufficient impervious, pervious, and riprap materials exist within 2-miles of the proposed damsite, and potential staging and lay down areas are located immediately upstream and downstream of the project site. An improved road provides access directly to the dam site and electrical power would likely be available from sources in Exeter or along Highway 198.

Most of the inundated area would be common grassland in Yokohl Valley. However, the valley may also support substantial wetland habitat, including vernal pools. Populations of the flower Tulare pseudobahia, (a.k.a. San Joaquin adobe sunburst, *Pseudobahia peirsonii*), a state-listed endangered and federally listed threatened species, are known to have occurred historically in Yokohl Valley. Other special status plants are also likely to be present. Impacts to wildlife would be low and no fish were observed in Yokohl Creek during the May 2002 field visit.

Numerous cultural resources, including pictographs, native gathering and processing sites, trails, and homesteads, are known to be present and there may be additional sites not yet recorded. Further site investigations and research regarding significance and mitigation requirements would be necessary. No recreational resources would be affected, only private lands. Land use impacts would be relatively low, and would be related to relocation of scattered residences along Yokohl Drive. The reservoir would be within the view of a new housing development off of Route 217 to the northwest.

No significant technical issues arise related to the physical ability to construct the proposed storage facility. With the exception of botanical and cultural resources, few adverse environmental impacts are anticipated to resources known to occupy the site. This option will be retained for further consideration.

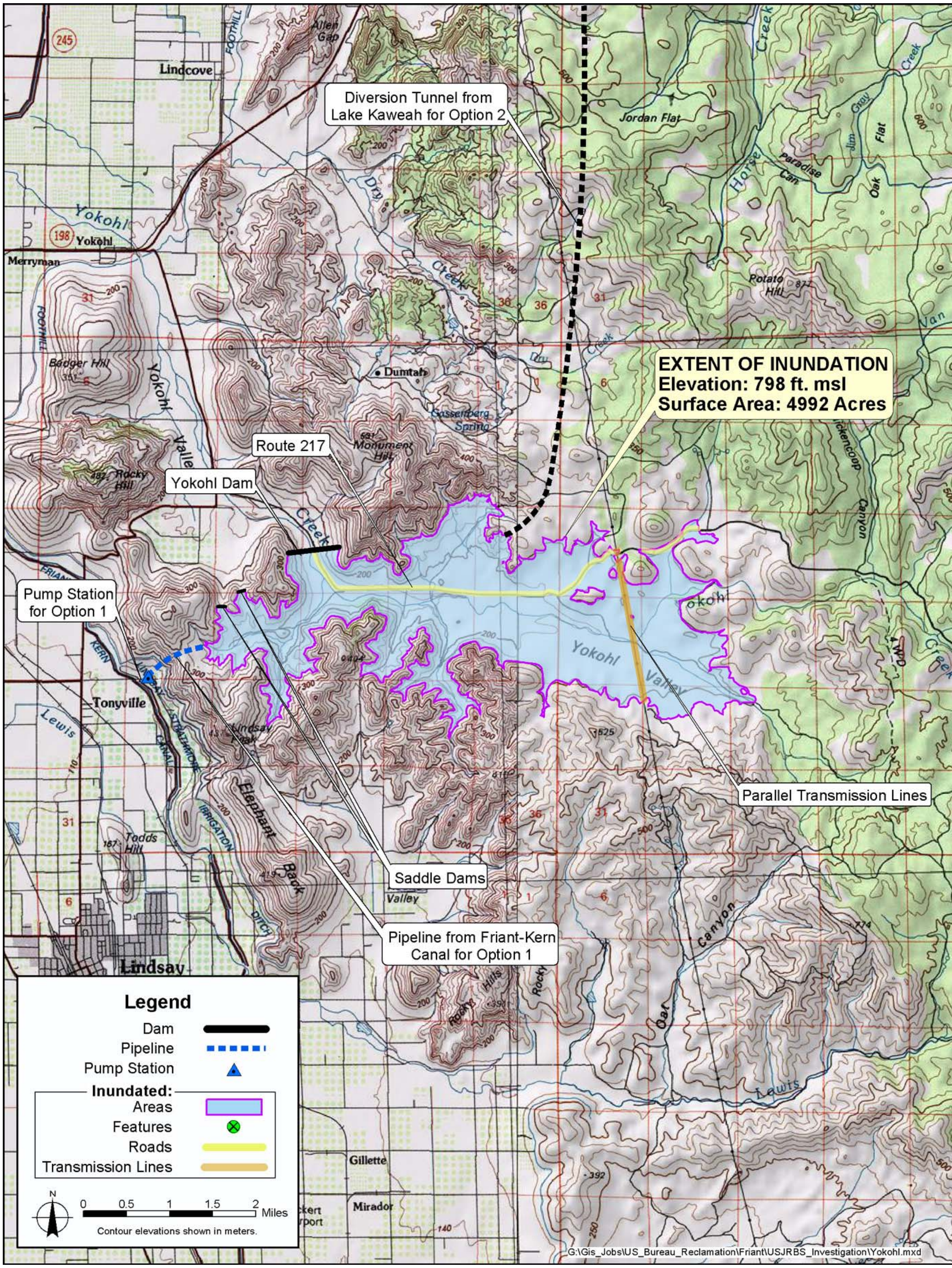

FIGURE 5-16. YOKOHL VALLEY RESERVOIR OPTION

Tule River Watershed - Hungry Hollow Dam and Reservoir

Description of Options

Hungry Hollow Dam and Reservoir would be constructed on Deer Creek, about 3 miles south of Lake Success and 6 miles east of Porterville. The new facility would be constructed on Deer Creek, a tributary to the Tule River, downstream of Success Dam and Reservoir. The dam would be a zoned earthfill structure 267 feet in height and 5,200 feet in length that would impound an off-stream reservoir with a storage capacity of up to 800,000 acre-feet (Figure 5-17). Additional features would include two saddle dams, a spillway, outlet works, and relief wells along the downstream toe of the dam.

Two configurations have been previously considered. The first would divert water from the Friant-Kern Canal via a two-way canal and pumping it into the reservoir. This would require three pump stations and two small regulating reservoirs. Stored water would be conveyed back to the Friant-Kern Canal. The second option involves diverting water from the Tule River at Lake Success and pumping it into Hungry Hollow Reservoir via a 10-foot diameter tunnel nearly 3 miles in length. In this case, stored water would be released down Deer Creek and diverted into the Friant-Kern Canal in exchange of releases from Millerton Lake.

Engineering and Environmental Findings

Extensive young alluvial deposits, over 300 feet thick, lie beneath the axis of the proposed dam. These deposits are unconsolidated, loose, permeable, and subject to liquefaction during an earthquake. Although no significant faults passing through the site have been identified, the alluvium would not provide an adequate foundation. Costly actions may be required to provide a suitable foundation – removal and recompaction or densification in place.

Other aspects of construction appear to pose little or no problem. Sufficient impervious, pervious, and riprap materials can be found within 2-miles of the dam site, potential staging and lay down areas are immediately upstream and downstream of the project site. Existing roads provide direct site access, and electrical power is likely available from sources in Porterville, along the county road within Hungry Hollow or Deer Creek valleys, or from high voltage power lines to the east.

Most of the inundated area would be common annual grassland. The reservoir would inundate up to 8 miles of Deer Creek, which supports well-developed sycamore alluvial woodland (SAW), an important regional wildlife habitat. Elderberry (Sambucus mexicana), the host plant for the valley elderberry longhorn beetle (a threatened species as listed by the federal government) is expected to be present in the riparian habitat. Wetland habitat may be present as well. Populations of fish and other organisms adapted to stream environments would be reduced or eliminated, while species suited to lake environments would be enhanced. Twenty-nine archaeological sites were identified in the late 1960s and it is likely that additional sites would be found with more extensive surveys.

This option has undesirable foundation conditions and would cause adverse and unmitigable affects to SAW habitat. It will be dropped from further consideration.

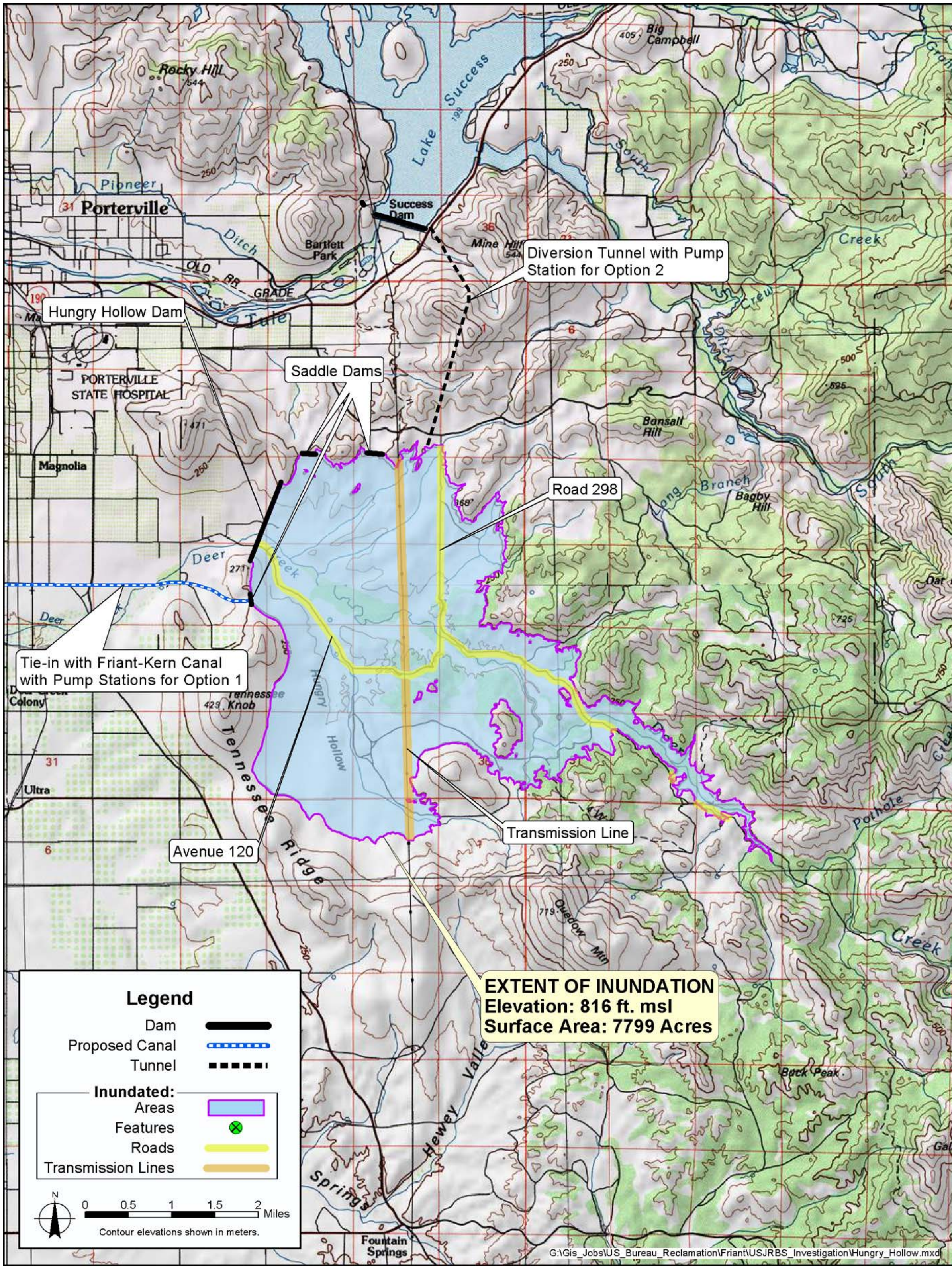

FIGURE 5-17. HUNGRY HOLLOW RESERVOIR OPTION

SUMMARY OF INITIAL SCREENING RESULTS

Table 5-2 summarizes the results of initial engineering and environmental screening of surface storage options. For each site, the table identifies undesirable engineering characteristics and potentially adverse environmental effects. The screening result to retain or drop is provided for each option.

The initial engineering review found that areas of primary concern relate to the stability of existing structures, geologic and seismic issues, and the quality of water that would be developed by the project. On the basis of this initial review, all other engineering issues were considered resolvable, although project costs would generally be proportionally higher for those options that required extensive preparation or rehabilitation.

The initial environmental review considered potential impacts to botany, wildlife, aquatic biology and water quality, recreation, and land use. Options that would result in adverse effects to environmental resources for which mitigation is not likely were dropped from further consideration.

TABLE 5-2
SUMMARY OF FINDINGS FROM CONSTRUCTABILITY SCREENING

Site	Option	Cap (1,000 TAF)	Engineering Considerations			Environmental Considerations					Retain / Drop
			DS	SG	WQ	Bot	WL	AB	Rec	LU	
Merced River Watershed											
Montgomery Reservoir	101 ft dam	241									Drop
San Joaquin River Watershed											
Friant Dam	up to 140 ft raise	870									Retain
Fine Gold Creek	up to 580 ft dam	780									Retain
Temperance Flat	up to 640 ft dam	1,273									Retain
Kerckhoff	up to 680 ft dam	1,986									Retain
Mammoth Pool	add spillway gates	35									Retain
Big Dry Creek Watershed											
Big Dry Creek Dam	long term storage	30									Drop
Kings River Watershed											
Pine Flat Dam	12 ft dam raise	124									Retain
Mill Creek	250 ft dam	200									Drop
Rodgers Crossing	400 ft dam	295									Drop
Dinkey Creek	340 ft dam	90									Drop
Kaweah River Watershed											
Dry Creek	200 ft dam	70									Drop
Yokohl Valley	260 ft dam	450									Retain
Tule River Watershed											
Hungry Hollow	267 ft dam	800									Drop

Key to Engineering and Environmental Considerations

Code	Meaning
DS	Safety of existing dam
SG	Soils and geology
WQ	Quality of developed water
Bot	Botany
WL	Wildlife
AB	Aquatic biology and water quality
Rec	Recreation
LU	Land use

Key to Assessments

Code	Meaning
	Unfavorable engineering, or operational conditions
	Further study needed to identify potential impacts
	Low or no likely adverse effects
	Likely adverse effects, mitigation to be determined
	Likely unmitigable adverse effects

CHAPTER 6. NEXT STEPS

The Phase 1 Investigation was initiated in Spring 2002 and is projected to complete in September 2003 with a final version of the Phase 1 Investigation Report. This In-Progress Review document is a status report that describes planning, technical, and public involvement work completed through December 2002. It is intended to provide an early review of work completed to date and the type of information that will be included in the Phase 1 Information Report. In summary, this document provides a status summary of the following topics:

- Background information on the Investigation,
- Existing and future conditions related to water project operations,
- Water resources problems and opportunities to be addressed in the Investigation,
- Plan formulation approach and tasks,
- Model development and application to the Friant Enlargement Concept,
- Initial screening of storage site options; and
- Public involvement approach.

The results of the modeling analysis provide initial direction for additional evaluations. As described in Chapter 4, the findings from Friant Enlargement Concept single-purpose evaluation suggest that modeling assumptions regarding the operation of Friant Dam could be further refined to more fully demonstrate how new storage could support river restoration and water quality objectives. Additional model refinements currently under way include potential new or enlarged facilities in the Upper San Joaquin River Basin and along the Friant-Kern Canal. Similar single-purpose evaluations will be made for retained storage options, as described in Chapter 4.

Planning tasks will shift toward development of a set of initial alternatives for consideration in Phase 2 study and the definition of continuation criteria. This will begin with a definition of functional equivalence criteria and a comparison of the retained options relative to the criteria. Continuation criteria will describe Federal, State, and user-group criteria that will be considered in a recommendation for continued study. Cost information for retained options will be used in combination with performance results to further screen options and a set of initial alternatives for consideration in Phase 2 study will be described.

Public involvement will continue through Phase 1. A series of eight stakeholder meetings (seven progress workshops and one topic-focused meeting) is described in Chapter 4. To date, this process is at a mid-point, with four meetings completed and four meeting remaining. The next workshop will focus on a review of this In-Progress Review document, a methodology for defining functional equivalence, and a discussion of continuation criteria.

The Draft Phase 1 Investigation Report is scheduled for release in June-July 2003 and the final report is scheduled for September 2003. Progress on the Investigation will continue as described above, pending FY 2003 Federal appropriations. Reclamation is not currently authorized to prepare a Feasibility Study for the Upper San Joaquin River Basin. Congressional authorization will be required before Phase 2 activities can begin.

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CHAPTER 7. REFERENCES

GENERAL REFERENCES USED FOR THE INVESTIGATION

CALFED, August 2000, CALFED Initial Surface Water Storage Screening.

California Division of Mines and Geology (CDMG), 1966 (fourth printing 1991), Geologic Map of California – Fresno Sheet, 1:250,000.

Carson, James D., USFWS, letter to U.S. Army Corps of Engineers regarding Tule River and Kaweah River Basin Investigations, January 23, 1989.

CDMG, 1966 (fourth printing 1981), Geologic Map of California – San Jose Sheet, 1:250,000.

CDMG, 1967 (fourth printing 1991), Geologic Map of California – Mariposa Sheet, 1:250,000.

CDMG, 1994, Fault Activity Map of California and Adjacent Areas with Locations and Ages of Volcanic Eruptions, 1:750,000, compiled by Charles W. Jennings.

Corps of Engineers (COE), Sacramento District, Department of the Army, United States, December 15, 1957, General Design Memorandum, Design Memorandum No. 5, Terminus Project, Kaweah River California.

COE, Sacramento District, Department of the Army, United States, December 1, 1958, General Design Memorandum (revised), Design Memorandum No. 6, Success Project, Tule River California.

COE, Sacramento District, Department of the Army, United States, August 1966, Terminus Reservoir, Geology, Paleontology, Flora and Fauna, Archeology, History.

COE, Sacramento District, South Pacific Division, Department of the Army, United States, September 1986, Kaweah and Tule River Reconnaissance Study, California, Hydrology.

COE, Sacramento District, South Pacific Division, Department of the Army, United States, July 1987, Tule River Basin Investigation, California, Reconnaissance Report.

COE, Sacramento District, Department of the Army, United States, March 1989, Kings River Basin Investigation, California.

COE, Sacramento District, South Pacific Division, Department of the Army, United States, August 1989b, Tule River Basin Investigation, California, Office Report, Feasibility Level, Basis of Design and Cost Estimate.

COE, Sacramento District, South Pacific Division, Department of the Army, United States, January 1990, Kaweah River Basin Investigation, California, Basis of Design and Cost Estimates, Office Report, Feasibility Level.

COE, Sacramento District, South Pacific Division, Department of the Army, United States, August 1990, Kaweah River Basin, California, Hydrology, Office Report, Feasibility Level.

COE, Sacramento District, South Pacific Division, Department of the Army, United States, August 1990, Tule River Basin, California, Office Report, Hydrology.

COE, Sacramento District, South Pacific Division, Department of the Army, United States, March 1992a, Tule River Basin Investigation, California, Interim Report.

COE, Sacramento District, South Pacific Division, Department of the Army, United States, March 1992b, Tule River Basin Investigation, California, Interim Report.

COE, Sacramento District, South Pacific Division, Department of the Army, United States, August 1993, Success Dam, Success Lake, Tule River, California, Dam Safety Assurance Program Reconnaissance Report, Seismic Evaluation.

COE, Sacramento District, South Pacific Division, Department of the Army, United States, April 1994, Pine Flat Dam Fish and Wildlife Habitat Restoration Investigation, California, Reconnaissance Report, Appendix C.

COE, Sacramento District, South Pacific Division, Department of the Army, United States, June 1996, Kaweah River Investigation, California, Draft Feasibility Report.

COE, Sacramento District, South Pacific Division, Department of the Army, United States, March 29 1999, Sacramento and San Joaquin River Basins, California, Post-Flood Assessment.

COE, Sacramento District, South Pacific Division, Department of the Army, United States, April 1999, Tule River Basin Investigation, California, Draft Feasibility Report.

DWR, Bulletin 160-98, California Water Plan Update, November 1998.

Enstrom, Karen, DWR, personal communication, December 2002.

Fish and Wildlife Service (USFWS), United States, September 1995, Environmental Effects of Yield Increase Options, A report to Congress.

International Engineering Company, Inc. (IECO), December 1974, Master Plan for Kings River Service Area, for Kings River Conservation District (KRCD).

Lendenmann, E.C., 1975, Draft Geologic Report, 2nd Draft, for Reclamation, Department of the Interior, United States.

Marchand, D, 1980, Preliminary Geologic Maps Showing Cenozoic Deposits of the Snelling and Merced Falls Quadrangles, Merced and Stanislaus Counties, California, Open-File Report 81-107, U.S. Geological Survey (USGS).

Prose, Caroline, USFWS, letter to the U.S. Army Corps of Engineers, February 7, 2002.

Reclamation, Mid-Valley Canal, East Side Division CVP, Department of the Interior, United States, 1974, Topographic Map, Sheets 1 through 6.

Reclamation, East Side Division CVP, Department of the Interior, United States, 1961a, Feasibility Design Estimate Drawings, Volume II.

Reclamation, East Side Division CVP, Department of the Interior, United States, 1961b, Cost Estimate-Project DC-1, Appendix, Volume III.

Reclamation, East Side Division CVP, Department of the Interior, United States, June 1966, A Feasibility of Water Supply Development.

Reclamation, East Side Division CVP, Department of the Interior, United States, September 1968, A Re-evaluation of the Report on the Feasibility of Water Supply Development.

Reclamation, 1971, Ground-Water Geology and Resources Appendix.

Saleeby, Jason, November 1974, Notes on mafic, ultramafic and associated metasedimentary rocks of the southwestern Sierra Nevada Foothills.

URS, November 22, 2000, Technical Memorandum 4, Draft Long List of Alternatives, Development of Water Supply Alternatives for Use in Habitat Restoration for the San Joaquin River, for Friant Water Users Authority and Natural Resources Defense Council Coalition.

URS, May 24, 2001, Technical Memorandum 5, Analysis of Long List of Alternatives, Development of Water Supply Alternatives for Use in Habitat Restoration for the San Joaquin River, for Friant Water Users Authority and Natural Resources Defense Council Coalition.

ADDITIONAL REFERENCES USED FOR DINKEY CREEK RESERVOIR

Kistler, R.W. and P.C. Bateman (1966), Stratigraphy and Structure of the Dinkey Creek Roof Pendant in the Central Sierra Nevada, California, Geological Survey Professional Paper 524-B, for Unites States geological Survey (USGS), Department of the Interior, United States.

ADDITIONAL REFERENCES USED FOR FINE GOLD RESERVOIR

DWR, Department of Public Works, State of California, January 2002, Draft - Reconnaissance Survey of Fine Gold Creek Reservoir.

WAVE Engineers, Inc. (WAVE), February 1991, Initial Operation Study, Fine Gold Water Conservation Project, for Madera Irrigation District.

REFERENCES USED IN THE FRIANT DAM ENLARGEMENT TM

Friant Water Users Authority, Information Report on Friant Division Water Deliveries.

Hill, L.K., July 21, 1952, Additional water supply and economic analysis of possible raising of Friant Dam 60 feet in height, Case of Rank v. Krug, Civil No. 685-ND, for Bureau of Reclamation Office of the Regional Counsel, Department of the Interior, United States.

Lendenmann, Ernest C., May 1989, Geologic Data for Safety of Dams Modification Decision Analysis – Construction Geologic Data and General Summary of Construction Concrete Data, for Friant Division - Central Valley Project, Regional Geology Section, Bureau of Reclamation Mid-Pacific Region, Department of the Interior, United States.

Murphy, F.M., January 15, 1937, Geological Report on the Friant Damsite – Central Valley Project, for Friant Division, Bureau of Reclamation, Department of the Interior, United States.

Reclamation, Department of the Interior, United States, April 1952, Friant Dam Raising, Earth Dikes, Crest El. 646.

Reclamation, Region 2, Department of the Interior, United States, July 1982, Friant Dam, Reconnaissance Estimate.

Reeves, Christopher R., Geologic Data for Modification Decision Analysis, Safety of Dams Studies, Friant Dam, Saddle Dams (Dikes) and Friant-Kern Canal, Station 145 to Station 155, for Friant Division - Central Valley Project, Regional Geology Section, Bureau of Reclamation Mid-Pacific Region, Department of the Interior, United States.

Additional References Used for Hungry Hollow Reservoir

Binkley, Margaret D., January 12, 1961, Deer Creek Pump Connection and Hungry Hollow Pumping Plant Intake Channel Engineering Geology for Feasibility Cost Estimates, for Bureau of Reclamation, East Side Division CVP, Conveyance Unit, Department of the Interior, United States.

Reclamation, Mid-Valley Canal, East Side Division CVP, Conveyance Unit, Department of the Interior, United States, July 1960, Hungry Hollow Dam, Basic Estimate DC-1, Reconnaissance Estimate.

Reclamation, East Side Division CVP, Department of the Interior, United States, March 10, 1961c, Hungry Hollow Dam, Reconnaissance Design Drawing.

Additional References Used for Mammoth Pool Dam and Reservoir

Southern California Edison, January 1982, Mammoth Pool Reservoir Spillway Gates, Conceptual Engineering Report.

Additional References Used for Montgomery Reservoir

CALFED, Storage and Conveyance Refinement Team, 1997, Facilities Descriptions and Updated Cost Estimates for Montgomery Reservoir.

Department of Water Resources (DWR), Department of Public Works, State of California, December 2000, Draft - Reconnaissance Survey of Montgomery Reservoir.

Fish and Wildlife Service (USFWS), United States, December 1992, Planning Aid Report – San Joaquin River Basin Resource Initiative – Montgomery Offstream Storage Reservoir.

Reclamation, East Side Division CVP, Department of the Interior, United States, February 5, 1959, Montgomery Dam and Reservoir Site, Preliminary Geology.

San Joaquin River Management Program Wildlife Committee (SJRMPWC), June 1993, Montgomery Offstream Storage Reservoir Proposal Memorandum.

ADDITIONAL REFERENCES USED FOR PINE FLAT RESERVOIR ENLARGEMENT

Barnes, S.M., Henry Karrer, Wm. H. McGlasson, J.F. Sorenson, and Robert E Leake, Jr., November 16, 1965, Progress Report of Engineering Committee on Kings River Water Utilization Projects Upstream from Pine Flat Reservoir, for Kings River Water Association.

COE, Sacramento District, Department of the Army, United States, October 1976, Pine Flat Lake, Kings River, California, Master Plan, Design Memorandum No. 7.

COE, Sacramento District, Department of the Army, United States, August 1989a, Environmental Assessment Reconnaissance Study for Flood Control for Pine Flat Dam, Kings River.

COE, Sacramento District, Department of the Army, United States, September 1989, Pine Flat Dam, Kings River, California, Reconnaissance Report.

Reclamation, Department of the Interior, United States, November 15, 1930, Pine Flat Dam, California Water Resources Investigations, Preliminary Estimate.

ADDITIONAL REFERENCES USED FOR TEMPERANCE FLAT RESERVOIR

Forbes, Hyde, Engineering Geologist, March 1930, Geological Report on Friant, Fort Miller, and Temperance Flat Damsites on San Joaquin River, for Division of Water Resources, Department of Public Works, State of California.

ADDITIONAL REFERENCES USED FOR YOKOHL VALLEY RESERVOIR

Hall, Charles E., July 28, 1958, Memorandum for Geology Files, Geologic Reconnaissance – Yokohl, Owens Mountain, Windy Gap, Buchanan, Hidden and Bailey Flat Dam Sites – East Side Investigations for the Fresno-Chowchilla Project, for Reclamation, East Side Division CVP, Department of the Interior, United States.

Kohl, W.P., May 1958, Field Inspection of the proposed Yokohl and Upper Owens Mountain dam sites for the East Side Investigation and Windy Gap, Bailey Flats, Hidden and Buchanan sites for the Fresno-Chowchilla Project, for Reclamation, East Side Division CVP, Department of the Interior, United States.

Lendenmann, E.C., February 12, 1975, Yokohl Damsite, Mid-Valley Canal, Geologic Log of Boring, DH-1, for Reclamation, Department of the Interior, United States.

Reclamation, Mid-Valley Canal, East Side Division CVP, Department of the Interior, United States, undated, Geologic Map showing Yokohl Damsite and Dike Sites.

Reclamation, Mid-Valley Canal, East Side Division CVP, Dams Unit, Department of the Interior, United States, March 24, 1972, Yokohl Dam and Reservoir, Reconnaissance Flood Hydrology, Cross Valley Investigation.

Reclamation, Mid-Valley Canal, East Side Division CVP, Dams Unit, Department of the Interior, United States, March 22, 1972, Reconnaissance Cost Estimates for Yokohl Creek Reservoir Pumping Plant, Pump Line and Other Features, Cross Valley Canal Studies - East Side Division - Central Valley Project.

Reclamation, Department of the Interior, United States, December 1974 through April 7, 1975, Reconnaissance Cost Estimates for Yokohl Dam and Reservoir.

Reclamation, Mid-Valley Canal, East Side Division CVP, Dams Unit, Department of the Interior, United States, March 23, 1972, Yokohl Dam and Reservoir, Cross Valley Investigation Central Valley Project.

Water and Power Resources Service, Department of the Interior, June 20, 1980, Central Valley Project, Eastside Division, Surface Geology, Yokohl Reservoir and Tunnel Alignment.

Water and Power Resources Service, Department of the Interior, June 25, 1980, Central Valley Project, Eastside Division, Proposed Borrow Areas, Yokohl Dam and Reservoir.

CHAPTER 8. GLOSSARY, ABBREVIATIONS, AND ACRONYMS

GLOSSARY

A

Acre-foot—The volume of water necessary to cover one acre to a depth of one foot. Equal to 43,560 cubic feet, 325,851 gallons, or 1,233 cubic meters. Depending on location and lot size, an acre-foot generally considered enough water to meet the needs of up to two California single-family households.

Affected environment—Existing biological, physical, social, and economic conditions of an area subject to change, both directly and indirectly, as a result of a proposed human action.

Air quality—Measure of the health-related and visual characteristics of the air, often derived from quantitative measurements of the concentrations of specific injurious or contaminating substances.

Aluvium—Soil transported by water in suspension and deposited by sedimentation.

Anthropogenic—Human-created.

Anadromous—In general, this term refers to fish such as salmon or steelhead trout that hatch in fresh water, migrate to and mature in the ocean, and return to freshwater as adults to spawn. Section 3403(a) of the CVPIA defines anadromous as "those stocks of salmon (including steelhead), striped bass, sturgeon, and American shad that ascend the Sacramento and San Joaquin rivers and their tributaries and the Sacramento-San Joaquin Delta to reproduce after maturing in San Francisco Bay or the Pacific Ocean".

Anadromous Fish Restoration Program (AFRP)—A program authorized by the CVPIA to address anadromous fish resource issues in Central Valley streams that are tributary to the Delta. This program is lead by the U.S. Fish and Wildlife Service (Service).

Applied Water (AW)—The quantity of water delivered to the intake to a city's water system or a farm headgate, the amount of water supplied to a marsh or other wetland, either directly or by incidental drainage flows.

Appropriative water rights—Water rights based upon the principle of prior appropriations, or "first in time, first in right". In order to maintain appropriative water rights, the right to any water must be put to beneficial use. Nonuse of appropriative water rights may result in the loss of those water rights. In a conflict between a riparian water user and an upstream appropriator, the riparian user has priority, provided that the water is being used in a reasonable and beneficial manner.

Aquatic—Living or growing in or on the water.

Aquifer—A geological formation capable of producing and storing water.

Authorization—An act by the Congress of the United States which authorizes use of public funds to carry out a prescribed action.

B

Baseload—Most commonly referred to as baseload demand, this is the minimum amount of power that a utility or distribution company must make available to its customers, or the amount of power required to meet minimum demands based on reasonable expectations of customer requirements. Baseload values typically vary from hour to hour in most commercial and industrial areas.

Basin Irrigation Efficiency—Evapotranspiration of applied water divided by the net diversion.

Bay-Delta Plan Accord—In December 1994, representatives of the state and federal governments and urban, agricultural and environmental interests agreed to the implementation of a Bay-Delta protection plan through the SWRCB, in order to provide ecosystem protection for the Bay-Delta Estuary. The Draft Bay-Delta Water Control Plan, released in May 1995, superseded D-1485.

Beneficial use—Those uses of water as defined in the State of California Water Code (Chapter 10 of Part 2 of Division 2), including but not limited to agricultural, domestic, municipal, industrial, power generation, fish and wildlife, recreation, and mining.

Benthic—Bottom of rivers, lakes, or oceans; organisms that live on the bottom of water bodies.

Biological assessment—An evaluation, in accordance with Section 7 of the Endangered Species Act, to determine the potential presence of threatened or endangered species and the potential for a proposed action to affect its habitat.

Biological opinion—Document issued under the authority of the Endangered Species Act stating the Service and/or the National Marine Fisheries Service (NMFS) finding as to whether a Federal action is likely to jeopardize the continued existence of a threatened or endangered species or result in the destruction or adverse modification of critical habitat. This document may include:

Critical habitat—A description of the specific areas with physical or biological features essential to the conservation of a listed species and which may require special management considerations or protection. These areas have been legally designated via Federal Register notices.

Jeopardy opinion—The Service or NMFS opinion that an action is likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat. The finding includes reasonable and prudent alternatives, if any.

No jeopardy opinion—U.S. Fish and Wildlife Service or NMFS finding that an action is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat.

C

CALFED—Joint federal and state program to address water-related issues in the Sacramento-San Joaquin rivers Delta.

Candidate species—Plant or animal species not yet officially listed as threatened or endangered, but which is undergoing status review by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service.

Carryover storage—That water remaining in storage at the end of the water year.

Catch—At a recreational fishery, refers to the number of fish captured.

Central Valley Habitat Joint Venture—As defined by Section 3403(c) of the CVPIA, "the association of Federal and State agencies and private parties established for the purpose of developing and implementing the North American Waterfowl Management Plan as it pertains to the Central Valley of California".

Central Valley Project (CVP)—As defined by Section 3403(d) of the CVPIA, "all Federal reclamation projects located within or diverting water from or to the watershed of the Sacramento and San Joaquin rivers and their tributaries as authorized by the Act of August 26, 1937 (50 Stat. 850) and all Acts amendatory or supplemental thereto, ...".

Central Valley Project service area—As defined by Section 3403(e) of the CVPIA, "that area of the Central Valley and San Francisco Bay Area where water service has been expressly authorized pursuant to the various feasibility studies and consequent congressional authorizations for the Central Valley Project".

Central Valley Project water—As defined by Section 3403(f) of the CVPIA, "all water that is developed, diverted, stored, or delivered by the Secretary in accordance with the statutes authorizing the Central Valley Project in accordance with the terms and conditions of water rights acquired pursuant to California law".

Central Valley Project Water Service Contractor—Water users that have contracted with the U.S. Bureau of Reclamation for water developed by and conveyed through CVP facilities.

Channel—Natural or artificial watercourse, with a definite bed and banks to confine and conduct continuously or periodically flowing water.

Confined aquifer—An aquifer bounded above and below by impermeable or confining layers of distinctly lower permeability than the aquifer itself.

Confluence—The flowing together of two or more streams; the place of meeting of two streams.

Conjunctive water management—The planned use of groundwater in conjunction with surface water in overall management to increase the use of water resources.

Conserved water—That water resulting from the contractor operations and practices that results in less use of the allocated supply.

Conveyance capacity—The rate at which water can be transported by a canal, aqueduct, or ditch. In this document, conveyance capacity is generally measured in cubic feet per second.

Conveyance losses—Evaporation, evapotranspiration and seepage losses in major conveyance canals.

Cooperating agency—An agency that meets the following criteria: (1) is included in 40 CFR Chapter V, Council on Environmental Quality (CEQ) Rules and Regulations, Appendix 1 - Federal and Federal-State agency National Environmental Policy Act (NEPA) contacts; and/or (2) has study area-wide jurisdiction by law or special expertise on environmental quality issues; (3) has been invited by the lead agency to participate as a cooperating agency; and (4) has made a commitment of resources (staff and/or funds), for regular attendance at meetings, participation in workgroups, in actual preparation of portions of the programmatic environmental impact statement (PEIS), and in providing review and comment on activities associated with the PEIS as it progresses. The role of the cooperating agency is documented in a formal memorandum of agreement with the lead agency.

Cost-of-service water rates—The water rate charged to recover all operating and capital costs, and individual contractor operating deficits, associated with the providing of water service. Components of operation and maintenance (O&M) and capital cost vary by contractor depending on services required for water delivery. Differs from full cost in that no charge for interest on capital is included.

Cubic feet per second—A measure of the volume rate of water movement. As a rate of streamflow, a cubic foot of water passing a reference section in 1 second of time. One cubic foot per second equals 0.0283 m3/s (7.48 gallons per minute). One cubic foot per second flowing for 24 hours produces approximately 2 acre-feet.

D

Decision -1641 (D-1641)—The SWRCB decision specifying water quality standards for the Sacramento-San Joaquin Delta and Suisun Marsh.

Dedicated Water—Refers to the 800,000 acre feet of CVP yield identified in Section 3406(b)(2) of the CVPIA that the Secretary must dedicate and manage for the primary purpose of implementing the fish and wildlife purposes and measures of the act, to help California protect the Bay-Delta estuary, and to help meet legal obligations imposed on the CVP under state and federal law, including the Federal Endangered Species Act (ESA).

Deep Percolation—Percolation of applied water and precipitation below the root zone of plants.

Deficiencies—Reductions in deliveries of contracted water. The amount of the reduction is expressed as the percent of full annual contract amount.

Delta—A low, nearly flat alluvial tract of land formed by deposits at or near the mouth of a river. In this report, delta usually refers to the delta formed by the Sacramento and San Joaquin rivers.

Density—The mass of a substance per unit of volume of that substance; i.e., the density of water changes with changes in temperature.

Depletion—Represents water consumed in a service area or no longer available as a source of supply.

Depletion study area—An analysis unit defined by the California Department of Water Resources for water resources planning investigations. Defined as the division of large drainage areas into smaller drainage and service areas from which water supplies and demands can be evaluated.

Dissolved oxygen (D.O.)—The concentration of free (not chemically combined) molecular oxygen (a gas) dissolved in water, usually expressed in milligrams per liter, parts per million, or percent of saturation. Adequate concentrations of dissolved oxygen are necessary for the life of fish and other aquatic organisms and the prevention of offensive odors. DO levels are considered the most important and commonly employed measurement of water quality and indicator of a water body's ability to support desirable aquatic life.

Dry-farmed—Crop production without the use of applied water.

E

Endangered species—Any species or subspecies of bird, mammal, fish, amphibian, reptile, or plant which is in serious danger of becoming extinct throughout all, or a significant portion of its range. Federally endangered species are officially designated by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service and published in the Federal Register.

Endemism—Native or limited to a certain region (endemic).

Enhancement—Measures which develop or improve the quality or quantity of existing conditions or resources beyond a condition or level that would have occurred without an action; i.e., beyond compensation.

Entrainment—The drawing of fish and other aquatic organisms into water diversions.

Environmental consequences—The impacts to the Affected Environment that are expected from implementation of a given alternative.

Environmental Impact Statement (EIS)—An analysis required by the National Environmental Policy Act (NEPA) for all major Federal actions, which evaluates the environmental effects of alternative actions.

Ephemeral stream—Flows briefly only in direct response to precipitation.

Epilimnion—The upper, wind-mixed layer of a thermally stratified lake. This water is turbulently mixed throughout at least some portion of the day and because of its exposure, can freely exchange dissolved gases (such as O2 and CO2) with the atmosphere

Escapement—Number of salmon that actually return to a stream to spawn.

Estuary—A water passage where the tide meets a river current; an arm of the sea at the lower end of a river.

Evaporation—The change of a substance from the solid or liquid phase to the gaseous (vapor) phase.

Evapotranspiration (ET)—Water evaporated from plant and soil surfaces or transpired by plant tissues.

Evapotranspiration of Applied Water (ETAW)—Portion of the evapotranspiration provided by the applied water.

Exotic species—Any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem; and whose introduction does or is likely to cause economic or environmental harm or harm to human health.

Extirpated species—A species that has become extinct in a given area.

F

Fallowed land—Cultivated land that lies idle during a growing season.

Field Irrigation Efficiency—The efficiency of water application. Computed by dividing the evapotranspiration of applied water by applied water and converting the result to a percentage. Efficiency may be computed at three levels: farm, district, or basin.

Fill—A man-made deposit of soil or other materials.

Firm water supplies—Non-interruptible water supplies guaranteed by the supplier to be available at all times except for reasons of uncontrollable forces or continuity of service provisions.

Fish ladders—A series of ascending pools constructed to enable salmon or other fish to swim upstream around or over a dam.

Fish passage facilities—Features of a dam that enable fish to move around, through, or over without harm. Generally an upstream fish ladder or a downstream bypass system.

Flow—The volume of water passing a given point per unit of time.

Instream flow requirements—Amount of water flowing through a stream course needed to sustain instream values.

Minimum flow—Lowest flow in a specified period of time.

Peak flow—Maximum instantaneous flow in a specified period of time.

Return flow—Portion of water previously diverted from a stream and subsequently returned to that stream or to another body of water.

Fry—Life stage of fish between the egg and fingerling stages.

G

Geographic Information System (GIS)—A computer system which allows for input and manipulation of geographic data to allow researchers to manipulate, analyze and display the information in a map format.

Groundwater—Water stored underground in pore spaces between rocks and in other alluvial materials and in fractures of hard rock occurring in the saturated zone.

Groundwater level—Refers to the water level in a well, and is defined as a measure of the hydraulic head in the aquifer system.

Groundwater overdraft—A condition of a groundwater basin in which the amount of water withdrawn by pumping exceeds the amount of water that recharges the basin over a period of years, during which water supply conditions approximate average.

Groundwater pumping—Quantity of water extracted from groundwater storage.

Groundwater table—The upper surface of the zone of saturation, except where the surface is formed by an impermeable body.

H

Habitat—Area where a plant or animal lives.

Hypolimnion—The bottom, and most dense layer of a stratified lake. It is typically the coldest layer in the summer and warmest in the winter. It is isolated from wind mixing and typically too dark for much plant photosynthesis to occur.

I

Indicator species—Organism, species, or community which indicates presence of certain environmental conditions.

Interest group—An agency or other entity that has expressed an interest, verbally or in writing, in becoming more involved in the development of a planned project.

Intermittent or seasonal stream—Stream on or in contact with the groundwater table that flows only at certain times of the year when the groundwater table is high.

Irrigation water—Water made available from the project that is used primarily in the production of agricultural crops or livestock, including domestic use incidental thereto, and the watering of livestock. Irrigation water does not include water used for domestic uses such as the watering of landscaping or pasture for animals (e.g., horses) which are kept for personal enjoyment. It generally does not include water delivered to landholdings operated in units of fewer than 2 acres, unless the contractor establishes to the satisfaction of the contracting officer that the use of the water delivered to any such landholding is a use within this definition.

J

Juvenile—Young fish older than 1 year but not having reached reproductive age.

L

Land classification—An economic classification of variations in land reflecting its ability to sustain long-term agricultural production.

Land retirement—Permanent or long-term removal of land from agricultural production.

Level 2—A term used to refer to refuge water supply deliveries. The 1989 and 1992 Refuge Water Supply Studies define Level 2 refuge water supplies as the average amount of water the refuges received between 1974 and 1983.

Level 4—A term used to refer to refuge water supply deliveries. Level 4 refuge water supplies are defined in the 1989 and 1992 Refuge Water Supply Studies as the amount of water for full development of the refuges based upon management goals developed in the 1980s. The CVPIA authorized purchase of the Level 4 increment, the difference between Level 2 and Level 4 amounts.

Limnology—Scientific study of the physical characteristics and biology of lakes, streams, and ponds.

Long-term contract—Contracts with terms of more than 10 years.

M

Mainstem—The main course of a stream.

Mitigation—One or all of the following: (1) Avoiding an impact altogether by not taking a certain action or parts of an action; (2) minimizing impacts by limiting the degree or magnitude of an action and its implementation; (3) rectifying an impact by repairing, rehabilitating, or restoring the affected environment; (4) reducing or eliminating an impact over time by preservation and maintenance operations during the life of an action; and (5) compensating for an impact by replacing or providing substitute resources or environments.

Model—A tool used to mathematically represent a process that could be based upon empirical or mathematical functions. Mathematical models can be computer programs, spreadsheets, or statistical analyses.

N

Natural production—As defined by Section 3403(h) of the CVPIA, "fish produced to adulthood without direct human intervention in the spawning, rearing, or migration processes".

Nonconsumptive water use—Water uses including swimming, boating, waterskiing, fishing, maintenance of stream-related fish and wildlife habitat, hydropower generation, and other uses that do not substantially deplete water supplies.

Non-Recoverable Loss—Losses to salt sinks, or evaporation and evapotranspiration in conveyance and drainage canals. Expressed as a percentage of evapotranspiration of applied water.

O

Operating non-Federal entity—A Non-Federal entity that operates and maintains Federal facilities pursuant to an agreement with the United States.

P

Percolation—In the context of this report, the downward movement of water through the soil or alluvium to the groundwater table.

Perennial stream—Flows continuously throughout the year.

Place of use—The geographic area specified in a water right permit or license issued by the California State Water Resources Control Board, wherein the water may be used.

Point of diversion—The point along a river or stream that a water right permit or license specifies water may be diverted to areas away from the river.

Programmatic environmental impact statement—EIS prepared prior to a Federal agency's decision regarding a major program, plan, or policy. It is usually broad in scope and followed by subsequent more narrowly focused NEPA compliance documents such as site-specific environmental assessments and environmental impact statements.

Project repayment—The return to the Treasury of the reimbursable funds expended to construct, operate, maintain, and replace project facilities under the terms and conditions authorized by Congress plus other costs assigned by Congress.

Proposed action—Plan that a Federal agency intends to implement or undertake and which is the subject of an environmental analysis. Usually, but not always, the proposed action is the agency's preferred alternative for a project. The proposed action and all reasonable alternatives are evaluated against the no action alternative.

Public involvement—Process of obtaining citizen input into each stage of the development of planning documents. Required as a major input into any EIS.

R

Range—Geographic region in which a given plant or animal normally lives or grows.

Reasonableness criteria—Parameters established by the AFRP for determining the "reasonableness" of restoration actions. These parameters include: consideration of potential adverse economic and social impacts, public sentiment, the magnitude of benefits, the certainty that an action will achieve projected benefits, and the authority established by existing laws and regulations.

Recharge—The processes of water filling the voids in an aquifer, which causes the piezometric head or water table to rise in elevation.

Reclamation laws—As defined by Section 3403(I) of the CVPIA, "the Act of June 17, 1902 (82 Stat. 388) and all Acts amendatory thereof or supplemental thereto".

Reclamation Reform Act—The Reclamation Reform Act of 1982 (Public Law 97-293, 96 Stat. 1263) was signed by the President on October 12, 1982. While retaining the basic principle of limiting the amount of owned land which may receive irrigation water deliveries from Reclamation projects, the Act introduced the concept of full-cost pricing (including interest on the unpaid plant investment) for certain irrigation water deliveries to leased lands.

Record of Decision (ROD)—Concise, public, legal document which identifies and publicly and officially discloses the responsible official's decision on the alternative selected for implementation. It is prepared following completion of an EIS.

Redd—Depression in river or lake bed dug by fish for the deposition of eggs.

Refuge Water Supply Report—As defined by Section 3403(j) of the CVPIA, "the report issued by the Mid-Pacific Region of the Bureau of Reclamation of the U.S. Department of the Interior entitled Report on Refuge Water Supply Investigations, Central Valley Hydrologic Basin, California (March 1989)".

Repayment contract—As defined by Section 3403(k) of the CVPIA, "the same meaning as provided in sections 9(d) and 9(e) of the Reclamation Project Act of 1939 (53 Stat. 1187, 1195), as amended". See water service contract.

Reservoir—Artificially impounded body of water.

Reservoir storage capacity—Reservoir capacity normally usable for storage and regulation of reservoir inflows to meet established reservoir operating requirements.

Flood control storage capacity—Reservoir capacity reserved for the purpose of regulating flood inflows to reduce flood damage downstream.

Restoration Fund—As defined in Section 3403(l) of the CVPIA, "the Central Valley Project Restoration Fund established by this title".

Return flows—That water returned to the natural surface water system after use by the water user.

Riparian—Areas along or adjacent to a river or stream bank whose waters provide soil moisture significantly in excess of that otherwise available through local precipitation.

Riparian water rights—Exists for lands which abut a waterway, or which overly an underground stream. Generally, there is no riparian right to diffused surface waters or swamps. The extent of the frontage along a waterway in no way governs the quantity of the water right. Use of water through riparian rights must be on riparian land and within the watershed of the stream. Riparian rights may not be lost as a result of nonuse.

S

Sacramento River Settlement Contractors—Various irrigation districts, mutual water companies and other water users that hold Sacramento River Water Rights Settlement Contracts with the United States. The Settlement Contracts provide for the recognition of the contractors' underlying water rights to divert the natural flow of the Sacramento River, while also providing for a supplemental supply of Central Valley Project (CVP) project water during the summer months. Approximately 2.2 million acre-feet of water are diverted under the Settlement Contracts, serving approximately 440,000 acres between Redding and Sacramento.

Salmonids—Fish of the family Salmonidae, such as salmon, trout (including steelhead), and whitefish.

Scoping—The process of defining the scope of a study, primarily with respect to the issues, geographic area, and alternatives to be considered. The term is typically used in association with environmental documents prepared under the National Environmental Policy Act.

Secretary—The Secretary of the Interior.

Section 215 Water—Water defined under Section 215 of the Reclamation Reform Act of 1982 (RRA), as unstorable irrigation water to be released due to flood control criteria or unmanaged flood flows.

Seepage—Water that escapes control through canal lining, stream banks, or other holding or conveyance systems.

Shasta Criteria—Establishes when a water year is considered critical, based on inflow to Shasta Lake. When inflows to Shasta Lake fall below the defined thresholds, the water year is defined as critical, and water deliveries to Sacramento River Water Rights and San Joaquin River Exchange Contractors may be reduced up to 25 percent. A year is critical when the full natural inflow to Shasta Lake for the current water year (October 1 of the preceding calendar year through September 30 of the current calendar year) is equal to or less than 3.2 million acre-feet. This is considered a single-deficit. A year is also critical when the accumulated difference (deficiency) between 4 million acre-feet and the full natural inflow to Shasta Lake for successive previous years, plus the forecasted deficiency for the current water year, exceeds 800,000 acre-feet.

Short-term contract—Contracts with a term of more than 5 years but less than 10 years.

Semi-confined Aquifer—A condition where the movement of groundwater is restricted sufficiently to cause differences in head between different depth zones of the aquifer during periods of heavy pumping, but during periods of little draft the water levels recover to a level coincident with the water table.

Smolt—A juvenile salmon or steelhead migrating to the ocean and undergoing physiological changes to adapt its body from a freshwater to a saltwater environment.

Spawning—The releasing and fertilizing of eggs by fish.

Spill—Water released from reservoirs to comply with flood control criteria.

Spillway—Overflow structure of a dam.

Stream—Natural water course.

Subsidence—A local mass movement that involves principally the gradual downward settling or sinking of the earth's surface with little or no horizontal motion. It may be due to natural geologic processes or mass activity such as removal of subsurface solids, liquids, or gases, ground water extraction, and wetting of some types of moisture-deficient loose or porous deposits.

Surface water diversion—Total quantity of water removed from a stream.

Surface Water Return Flow (SWRF)—Percent of water that directly returns by surface to the stream.

T

Tailwater—Water immediately downstream of a dam.

Target Flows—Flow goals used in development of the Draft PEIS alternatives. The goals were based upon preliminary information developed for the AFRP Restoration Plan. The target flows were developed in a iterative process.

Temporary contract—Contract with a term of less than 5 years.

Threatened species—Legal status afforded to plant or animals species that are likely to become endangered within the foreseeable future throughout all or a significant portion of their range, as determined by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service.

Tiering—Procedure which allows an agency to avoid duplication of paperwork through incorporation by reference of the general discussions and relevant specific discussions from an environmental compliance document of broader scope into a subsequent document of narrower scope.

Total supply—Total water supply available to area (surface water plus groundwater).

Transfers, sales, and exchanges—A transfer or sale is a one way transaction to another contractor usually on an annual basis, but could be on a permanent basis. An exchange is a two-way transaction wherein a contractor transfers water to another contractor to be returned at a later date. CVP contractors may transfer, sell and exchange to other contractors their contractual water supply only with written consent from the United States.

Tributary—A stream feeding into a larger stream or a lake.

Turn outs—The physical structures along main canal systems for distribution of water.

U

Unimparied Flow—

W

Warren Act—The Warren Act of February 1, 1911 provides authority to convey and store non-project water within project facilities. Both non-project M&I and irrigation water can be stored or conveyed in project facilities. Section 1 of the Warren Act requires Reclamation to charge water contractors for the cost of conveying non-project water through project facilities. Unlike virtually all other CVP rates, Warren Act rate revenues are not creditable to project repayment and are returned directly to the U.S. Treasury.

Water acquisition—The purchase of water from willing sellers.

Water rights—California recognizes riparian and appropriative water rights.

Watershed—A region or area bounded peripherally by a water parting and draining ultimately to a particular watercourse or body of water.

Water year—Usually when related to hydrology, the period of time beginning October 1 of one year and ending September 30 of the following year and designated by the calendar year in which it ends.

Wetland—A zone periodically or continuously submerged or having high soil moisture, which has aquatic and/or riparian vegetation components, and is maintained by water supplies significantly in excess of those otherwise available through local precipitation.

Wildlife habitat—An area that provides a water supply and vegetative habitat for wildlife.

Willing sellers—A term used to describe individuals who would be interested in selling water supplies under transfer guidelines established by SWRCB and other regulatory agencies.

X

X2—Salinty criteria of two parts per thousand (2ppt) which must be maintained in Suisun Bay during the February through June spring runoff period.

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Abbreviations and Acronyms

AAQS	Ambient Air Quality Standards
AB	Assembly Bill
ACHP	Advisory Council on Historic Preservation
af	acre-foot (feet)
af/yr	acre-feet per year
AFRP	Anadromous Fish Restoration Program
AIRFA	American Indian Religious Freedom Act
AQMD	Air Quality Management District
ARB	Air Resources Board (California)
Bay-Delta	San Francisco Bay/Sacramento-San Joaquin Delta
BIA	U.S. Bureau of Indian Affairs
BLM	U.S. Bureau of Land Management
BMP	Best Management Practice
Caltrans	California Department of Transportation
CCAA	California Clean Air Act
CDEC	California Data Exchange Center
Census	U.S. Bureau of the Census
CEQA	California Environmental Quality Act
cf	cubic feet
cfs	cubic feet per second
CIMIS	California Irrigation Meteorologic Information System
CNPS	California Native Plant Society
COA	Coordinated Operating Agreement
COE	U.S. Army Corps of Engineers
CRHR	California Register of Historic Resources
CUWA	California Urban Water Agency
CVGSM	Central Valley Groundwater - Surface Water Simulation Model
CVHJV	Central Valley Habitat Joint Venture
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CVPM	Central Valley Production Model

CVP-OCAP	Central Valley Project Operations Criteria and Plan
CVRWQCB	Central Valley Regional Water Quality Control Board
CWA	Clean Water Act
D-1641	Decision 1641 (State Water Resources Control Board)
DAU	Detailed Analysis Unit
Delta	Sacramento-San Joaquin River Delta
DFA	California Department of Food and Agriculture
DFF	California Department of Forestry and Fire Protection
DFG	California Department of Fish and Game
DHS	California Department of Health Services
DMC	Delta-Mendota Canal
DO	dissolved oxygen
DOC	California Department of Conservation
DOF	California Department of Finance
DPR	California Department of Parks and Recreation
DWR	California Department of Water Resources
EA	environmental assessment
EC	electrical conductivity
EDF	Environmental Defense Fund
EIR	environmental impact report
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
FONSI	Finding of No Significant Impact
FWCA	Fish and Wildlife Coordination Act
FWUA	Friant Water Users Authority
GIS	geographic information system
GRCD	Grasslands Resource Conservation District
Interior	U.S. Department of the Interior
ITA	Indian Trust Asset
KCWA	Kern County Water Agency
kW	kilowatt

M&I	municipal and industrial
MAD	Mosquito Abatement District
MCL	maximum contaminant level
MCLGs	Maximum Contaminant Level Goals
mg/l	milligrams per liter
MOU	memorandum of understanding
mph	miles per hour
msl	mean sea level
MVCD	Mosquito and Vector Control District
MWD	Municipal Water District of Southern California
NAGPRA	Native American Graves Protection Repatriation Act
NAHC	Native American Heritage Commission
NAWMP	North American Waterfowl Management Plan
NDDB	Natural Diversity Database
NEPA	National Environmental Policy Act
NHL	National Historic Landmark
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Services
NO_X	Nitrogen Oxides
NO_2	Nitrogen Dioxide
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRA	National Recreation Area
NRDC	Natural Resources Defense Council
NRHP	National Register of Historic Places
NSDWR	National Secondary Drinking Water Regulations
NTU	nephelometric turbidity units
NWR	National Wildlife Refuge
NWS	National Weather Service
O_3	Ozone
O&M	Operations and Maintenance
OPR	California Office of Planning and Research
PDA	Public Domain Allotment

PEIS	Programmatic Environmental Impact Statement
PFMC	Pacific Fishery Management Council
PG&E	Pacific Gas and Electric Company
PM	particulate matter
PM_{10}	PM of 10 microns in aerometric diameter or less
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion; parts per thousand
psi	pounds per square inch
PSMFC	Pacific States Marine Fisheries Commission
RCD	Resource Conservation District
Reclamation	U.S. Bureau of Reclamation
RM	river mile
ROD	Record of Decision
ROG	reactive organic gases
ROP	Record of Progress
RVD	recreational visitor day
RWQCB	California Regional Water Quality Control Board
SCS	U.S. Department of Agriculture Soil Conservation Service
SDWA	Safe Drinking Water Act
Secretary	Secretary of the Interior
Service	U.S. Fish and Wildlife Service
SHPO	California State Historic Preservation Officer
SJRMP	San Joaquin River Management Program
SJVAB	San Joaquin Valley Air Basin
SJVDP	San Joaquin Valley Drainage Program
SJVUAPCD	San Joaquin Valley Unified Air Pollution Control District
SNA	Significant Natural Area
SPF	Standard Project Flood
SR	State Route
SRA	shaded riverine aquatic
SWP	State Water Project
SWRCB	State Water Resources Control Board

SWTR	Surface Water Treatment Rule
TAC	Toxic Air Contaminants
TAF	thousand acre-feet
TCD	temperature control device
TCPs	traditional cultural properties
TCR	total coliform rule
TDS	total dissolved solids
TMDL	total maximum daily load
TNC	The Nature Conservancy
TOC	total organic carbon
TOG	Total Organic Gases
USDA	U.S. Department of Agriculture
USDI	U.S. Department of the Interior
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
VELB	valley elderberry longhorn beetle
Western	Western Area Power Administration
WMA	Wildlife Management Area
WMP	Water Management Plan
WR	water rights
WUA	weighted usable area
WWD	Westlands Water District
WY	water year

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Appendix A

CALSIM II Model Modifications for Integration of Friant Division

Prepared by Walter Bourez, MBK Engineers and Dan Steiner, Consulting Engineer

INTRODUCTION

The operation of the Friant Division of the Central Valley Project (CVP) historically has not been represented in state-wide water planning models. The Friant Division is hydraulically connected with the San Joaquin River and can affect CVP South-of-Delta operations, particularly during flood events. The releases from Friant Dam to the San Joaquin River, along with an assumed Tulare Lake Basin overflow operation from the Kings River system, occasionally provide a water supply to the Mendota Pool, thereby potentially affecting the delivery of CVP water from the Delta-Mendota Canal, and thus affecting the West-side operation of the CVP and State Water Project (SWP). However, in recognition that Friant Dam has not been specifically operated for this purpose, simulated diversions to the Madera and Friant-Kern Canals have been depicted by regression equations based on historical deliveries. The models also included releases to the San Joaquin River to depict minimum release requirements for downstream riparian and contractor diversions, and flood control releases.

Current forums are investigating Friant Division operations for the potential of enhancing water supplies within the local area and for the benefit of other interests including a state-wide and Federal interest. Those investigations include assumptions for additional facilities, alternative operation plans, and alternative flow regimes below Friant Dam. To evaluate the performance of alternative facilities and plans, the operation of the Friant Division, as depicted in CALSIM II, required modifications. Fundamental to these modifications was the development of logic and assumptions for the existing (benchmark) operation of the Friant Division.

This documentation focuses on the development and implementation of (DEFINE) WRESL code and data assumptions for the benchmark depiction of Friant Division operations for the current level of development and operations.

MODEL PURPOSE AND SUMMARY DESCRIPTION

The benchmark model provides a tool that can depict current Friant Division water diversions and operations during a long-term simulation period (1922-1994). Canal diversions vary from year to year based on an annually variable water supply. The monthly distribution of an annual allocation is based on historical diversion practices, which are influenced by water delivery requirements and preferences of the contractors. Minimum required releases below Friant Dam for riparian and contractor users are modeled as a constant annual requirement, consistent with recent records of operations. Flood control operations for Millerton Lake and the lower San Joaquin River are based on the rainflood space reservation requirements specified by the U.S. Army Corps of Engineers (USACE). The flood control operation during the snowmelt runoff period recognizes the competing objectives of water supply and flood control. The operation attempts to maximize water supply carry-over storage (into summer) while reducing the potential for downstream flooding.

FIXED BOUNDARY INPUTS AND PARAMETERS

Several fixed parameters and simulated inputs are included in the benchmark model. These inputs and parameters represent attributes of Friant Division facilities or hydrology that do not vary.

Millerton Lake Area-Capacity-Evaporation

The Millerton Lake area-capacity relationship is depicted using a lookup table relating area to volume (Table A-1). The table was developed from data shown in the tables included in Report on Reservoir Regulation for Flood Control, Friant Dam and Millerton Lake San Joaquin River, California, Department of the Army, December 1955, Revised August 1980. Area is determined in CASLIM II by interpolating between storage values in the table. Monthly evaporation rates were estimated by DWR and input to CALSIM II as a timeseries.

TABLE A-1

MILLERTON LAKE AREA-CAPACITY RELATIONSHIPS

Storage (AF)	Area (Acres)
0	0
60,000	1,205
100,000	1,749
140,000	2,200
190,000	2,685
250,000	3,190
310,000	3,637
380,000	4,103
450,000	4,524
530,000	4,963

Millerton Lake Inflow

CALSIM II does not currently simulate the operations upstream of Millerton Lake. The benchmark model incorporates operations upstream of Millerton Lake consistent with the “Base Plan” results described in *Evaluation of Potential Increases in Millerton Lake Water Supply Resulting from Changes in Upper San Joaquin River Basin Projects Operation, Phase 2, U. S. Bureau of Reclamation, October 2000.* Input to the benchmark model derived from that study include inflow to Millerton Lake and the monthly storage at Mammoth Pool, as listed in Attachment A.

Flood Control Constraints and Operations

Flood control is an important aspect of Friant Division operations, and is guided by objectives included in *Report on Reservoir Regulation for Flood Control, Friant Dam and Millerton Lake San Joaquin River, California, Department of the Army, December 1955, Revised August 1980*. At any given time, Millerton Lake storage is within one of three zones: within the conservation space, when flood releases are not required; within the rainflood space, when water stored in this space (including credit for available storage space in Mammoth Pool) will be released as rapidly as possible without exceeding 8,000 cfs below Little Dry Creek, or 6,500 cfs at the Mendota gage; or within the conditional space, when releases are required in excess of irrigation demand, and are determined based on forecasted runoff, available upstream space and forecasted irrigation demand.

The required rainflood space is a fixed end-of-month constraint as identified in the Table A-2. During the heaviest precipitation months of November through January, 170,000 acre-feet of reserved space is maintained. The amount of space required in Millerton Lake (in excess of 85,000 acre-feet) is reduced by the amount of available space in Mammoth Pool. When necessary, CALSIM II logic creates a release to the San Joaquin River that is sufficient to not allow storage to encroach into the required rainflood space. The current version of CALSIM II is based on a monthly time-step and does not calculate instantaneous or peak flow rates. Therefore, the model does not constrain releases in consideration of the downstream flow objectives.

TABLE A-2

MILLETON LAKE RAINFLOOD SPACE

Rainflood Space(1,000 acre-feet)*											
Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
85	170	170	170	42	0	0	0	0	0	0	0
* Space in excess of 85,000 acre-feet can be replaced by an equal amount in Mammoth Pool											

During the conditional space time period (modeled February through June), an algorithm is used to simulate the management of flood volumes over the entire period. The release necessary to operate within the conditional flood control space is determined for each month between February and May. This is done by making a forecast of the quantity of water anticipated to be spilled by the end of June. The forecast requires an estimate of the available water supply, project deliveries, lake evaporation and minimum river releases through the end of June. The water supply forecast uses perfect foresight to predict the amount of Millerton inflow that will occur through the end of June. The deliveries, evaporation and minimum river releases through the end of June are estimated. Using the water supply forecast, delivery forecast, current storage, and end of June full reservoir storage target (520,000 acre-feet), the projected volume of spill through the end of June is computed. The projected spill volume is then distributed on a release schedule, which is consistent with historical reservoir flood control operation. Large projected spills are spread out over several months to surrogate the avoidance of large flows late in the season, while the release of small projected spill volumes is deferred until their release is necessary in May or June. The flood control release made for a given month is the greater of the computed rainflood release or the conditional space release.

The management (shaping) of river releases for operation within the conditional space is determined by user input matrices that establish river releases based on the forecast of spill volumes. A different matrix is used for each month of forecast from February through May. The matrix for a subsequent month only differs from the previous month's matrix by the amount of volume that is determined to be passed during the previous month. The algorithm is not operative during June as it is assumed that Millerton Lake has an objective to fill by the end of June, and any required spill in excess of minimum releases will be determined by the balance of operations during the month. Attachment A.2 shows the matrices for each month of forecasted operations.

Minimum Downstream Releases

Other than flood control releases, the release from Friant Dam to the San Joaquin River is limited to that amount necessary to maintain diversions by riparian and contractor users below Friant Dam at a location near Gravely Ford. Water diverted to the fish hatchery below Friant Dam and returned to the river partially serves that purpose. Review of historical operation records provided guidance in estimating the minimum downstream release used for the benchmark model. Attachment A.3 shows the historical record of release from Friant Dam to the river, inclusive of flood releases. From an analysis of the record (1990-1994) for periods when no flood control releases were made, an annual release of 116,700 acre-feet was estimated to be the current minimum release necessary to meet downstream diversions (including seepage). Table A-3 illustrates the assumed monthly distribution of this release requirement.

TABLE A-3

ESTABLISHED MINIMUM RIVER RELEASE REQUIREMENTS FROM MILLERTON LAKE

Estimated Minimum River Release Requirement from Millerton Lake (1,000 acre-feet)											
Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
10.1	7.4	6.7	4.5	5.0	6.6	9.0	10.9	12.9	14.4	15.7	13.4
Total: 116,700 acre-feet											

FRIANT DIVISION CANAL DIVERSIONS

Modeling canal diversions that are dependent on land use-based water demands is currently beyond the scope of this work effort. That effort will require significant additional analyses that concern the operation of other water resource supplies within the Tulare Lake Basin. At this time, the water diversions developed for the benchmark model mimic recent historical operations.

Delivery Patterns

A review of the historical record of water deliveries from the Friant Division was conducted. The record of those deliveries is contained in a database maintained by Reclamation. The protocol of the database attempts to categorize the different classifications of water deliveries made through the Friant Division. The review found several anomalies within the data, some of which could be explained by changing practices of classification (or institutional changes in classifications) and others that were apparently data entry errors or multiple accountings. Although questionable or possibly misinterpreted data were a problem, the review provided significant insight regarding the relationship between water supply availability and water delivery patterns for the Friant Division.

Most salient to this analysis are the data concerning monthly deliveries from the Friant-Kern Canal and the Madera Canal as water supply availability changes during a year. The data and analysis allowed development of a water delivery function based on water supply availability at Millerton Lake that is responsive to both flood control operations and other considerations within the basin that affect the delivery of water from the Friant Division, such as water availability from tributaries within the Tulare Lake Basin. Analysis also provided a coarse division of water deliveries between Class 1, Class 2, and other water classifications.

Tables A.4-1 and A.4-2 of Attachment A.4 list various components of historical recorded water deliveries from the Friant-Kern Canal. Tables A.4-3 and A.4-4 list the same components for water deliveries from the Madera Canal. Three components of deliveries are listed: "Class 1", "Class 2", and "Other". The reported Class 1 and Class 2 components are considered to be reasonably accurate and are acceptable for the purpose they are used in this planning-level model; however, as described earlier the database from which the values were derived contain occasional discrepancies with other records of deliveries. The record as presented in this documentation should not be used as the final statement of deliveries. Deliveries listed as "Other" were not quantitatively used in this analysis except as an indication of months when water other than Class 1 and Class 2 appeared to be delivered.

Figure A.4-1 of Attachment A.4 graphically illustrates the monthly delivery of water, as a percentage of total annual delivery, for both the Friant-Kern Canal and the Madera Canal. A depiction of Class 1 and total water deliveries is shown for each canal. There is substantial variability in the monthly distribution year-to-year. Analysis shows that definite trends occur between the total availability of water to Friant Division contractors and the pattern in which they take deliveries. Most significantly affecting the pattern is the availability of Class 2 water. The availability of Class 2 water proportionately concentrates deliveries during the spring-time and also affects the pattern that Class 1 deliveries are made to contractors that have both Class 1 and Class 2 supplies. During years with Class 2 water available, contractors with both Class 1 and Class 2 supplies will tend to shift their delivery of Class 1 supplies to later in the year, thus extending the period of deliveries.

The model's water delivery function distributes a forecasted volume of water supply into monthly deliveries to the Friant-Kern and Madera canals. Key to this distribution is the relationship between monthly deliveries and water supply availability. The model determines a forecasted volume of water availability. With that determination, the pattern of total water deliveries and the pattern of Class 1 deliveries are established. The product of the pattern and the water supply (limited by contract maximums) results in the monthly delivery of water. Inferred by the difference between the total delivery and the Class 1 delivery is Class 2 delivery.

From the many years of record, certain years of data were selected to develop guidance for establishing a water availability/delivery distribution pattern relationship. Years during which only Class 1 water was available provided an indication of the delivery pattern associated with limited water supplies, those years when no Class 2 supply was available. The pattern is used to distribute a water supply that equals or is less than 800,000 acre-feet (a full Class 1 supply). A second group of years was selected to represent the delivery patterns of Class 1 and total deliveries during years when the available water supply was near full Class1 and Class 2 allocations without exceeding a full Class 2 allocation (years when "Other" water may influence the delivery of Class 2 deliveries). Intermediate patterns between these two bounds of patterns were established to transition from the availability of only Class 1 supplies to the availability of full Class 1 and Class 2 supplies. Figures A-1 through A-4 illustrate the range of patterns used to distribute deliveries from the canals.

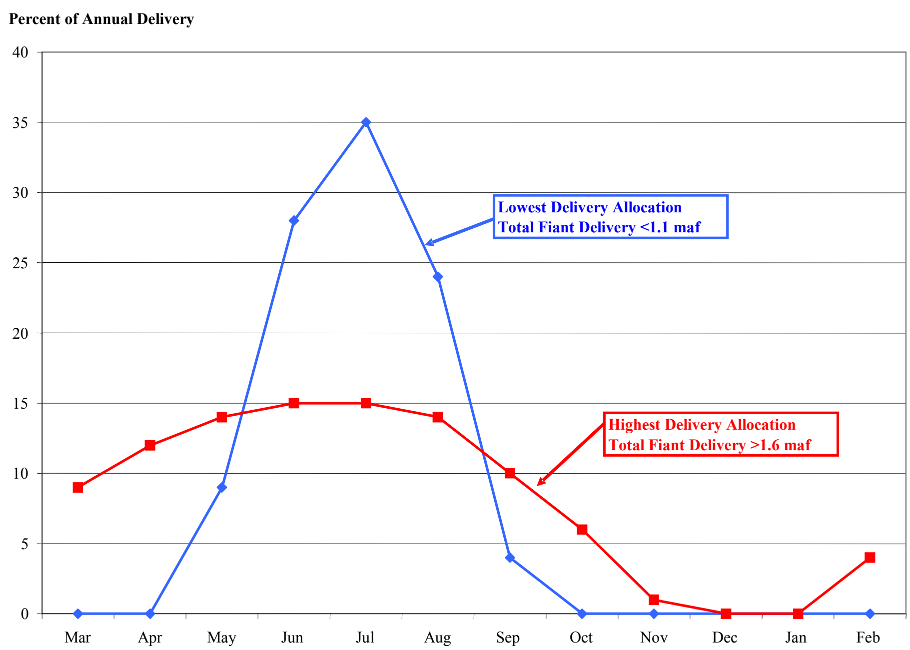

FIGURE A-1. MADERA CANAL TOTAL DELIVERY PATTERN

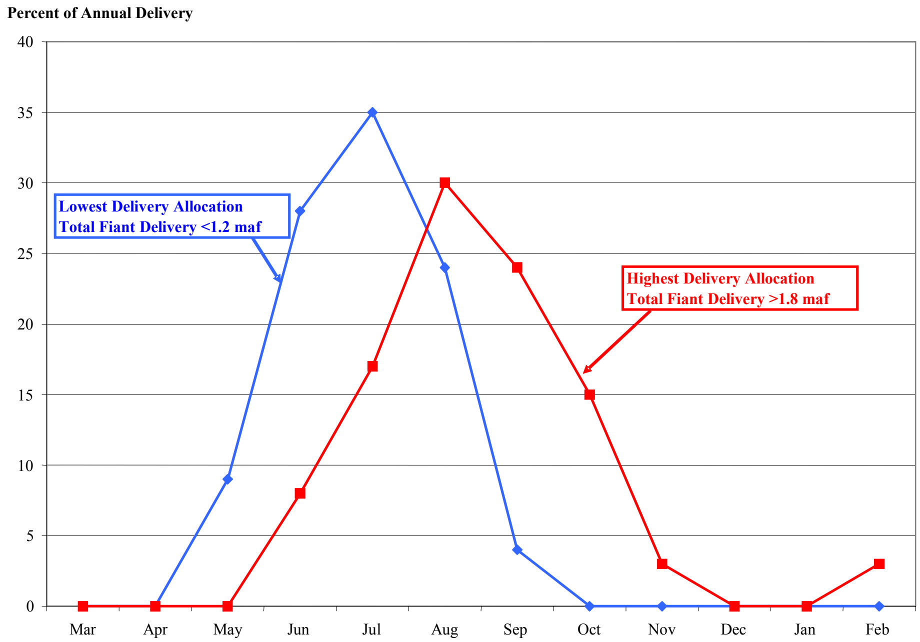

FIGURE A-2. MADERA CANAL CLASS 1 DELIVERY PATTERN

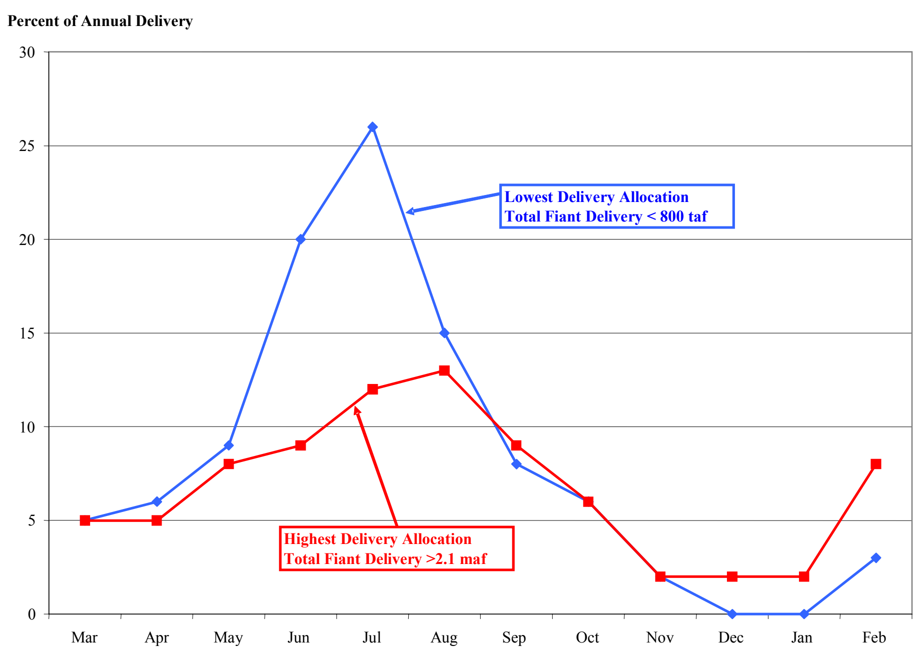

FIGURE A-3. FRIANT-KERN CANAL TOTAL DELIVERY PATTERN

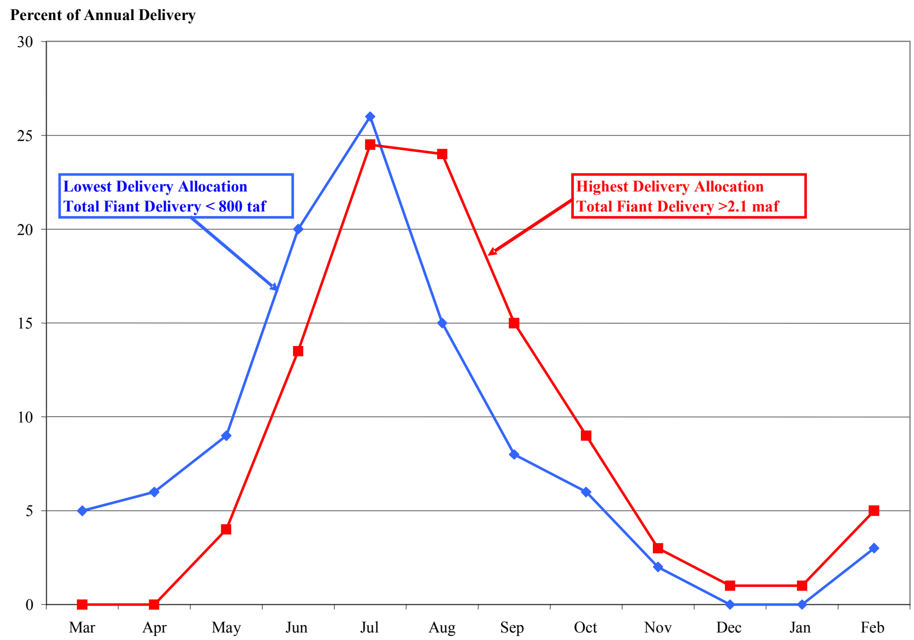

FIGURE A-4. FRIANT-KERN CANAL CLASS 1 DELIVERY PATTERN

Delivery Adjustments

Two adjustments are made to deliveries after initial allocations are made with the delivery logic. One is based on wetness in the Tulare Lake Basin and the other is based on flood control releases from Friant. Deliveries from the Friant-Kern canal are reduced when there is abundant surplus in the Tulare Lake Basin tributaries. This is a surrogate of the reduction in deliveries that occurs when Tulare Lake Basin water users are receiving flood flows from their local tributary projects. Conversely, deliveries to both the Friant-Kern and Madera Canals are increased when spills from Friant can be delivered. The model assumes an increased demand for water when Friant is spilling. The demand for surplus is a user-defined input to the model. The increased flood flow demand logic will not occur during months when the Tulare Lake Basin tributary logic reduces deliveries.

Canal Losses

Added to the synthesized water deliveries are canal losses that were developed through a comparison of historical water deliveries and canal diversions. Using the same selective analytical process of evaluating certain years and months of diversion and delivery data, an estimate of monthly un-accounted for diversions (losses) was developed. When modeled as being in operation (a diversion is occurring), the losses become an additional diversion requirement of the Madera and Friant-Kern Canals. The estimated canal losses are shown in Table A-4.

TABLE A-4

ESTIMATED CANAL LOSSES

Estimated Friant-Kern Canal Losses (1,000 acre-feet)											
Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
5	4	1	1	2	3	4	5	6	7	7	6
Estimated Madera Canal Losses (1,000 acre-feet)											
Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	2	3	4	3	0

BENCHMARK MODEL LOGIC

Delivery Logic

Annual water deliveries for the Friant Division are determined in March of each year and updated monthly through June. The allocation is estimated by summing the total water available from storage and inflow and subtracting requirements and losses. The remainder is the water available for delivery. The following equation is used to estimate water delivery at any point during the allocation season:

Water available for delivery:

= Sum current month through September Millerton inflow
+ Beginning of month Millerton Storage
- Millerton target (end of September) carryover storage
- Average current month through September evaporation
- Minimum Friant release to SJR for current month through September
- Losses for current month through September

Water is allocated to Class 1 and Class 2 deliveries based on the annual volume of available water. If the annual volume is less than the full Class 1 contract amount, Class 1 is set to the annual volume of available water. If the annual volume is greater than the Class 1 contract amount, Class 1 is set to full contract amount and the remainder is allocated to Class 2, up to the full Class 2 contract amount.

The monthly delivery patterns are based on the total annual volume of delivery. Lookup tables in the model contain the monthly delivery patterns (listed in Attachment A.5). Four lookup tables are used to determine monthly patterns for total delivery to the Friant-Kern and Madera canals and Class 1 delivery to the Friant-Kern and Madera canals. Monthly Class 2 delivery is the difference between total deliveries and Class 1 deliveries. The deliveries determined using this logic are based solely on water supply availability at Friant without consideration of wetness in the Friant service area and delivery of flood control releases. The adjustments for these factors are made subsequently in the model.

SIMULATION/VALIDATION

The water delivery function is integral to the development of the benchmark operation for the Friant Division. The total and separate annual canal diversions for the benchmark operation of the Friant Division are illustrated in Figures A.5 through A.7. Also shown are the historical canal diversions for the Friant Division. Most comparable are modeled and recorded diversions after 1961. Prior to 1961, Friant water user facilities were not completely built, and many of the facilities in the Tulare Lake Basin were incomplete.

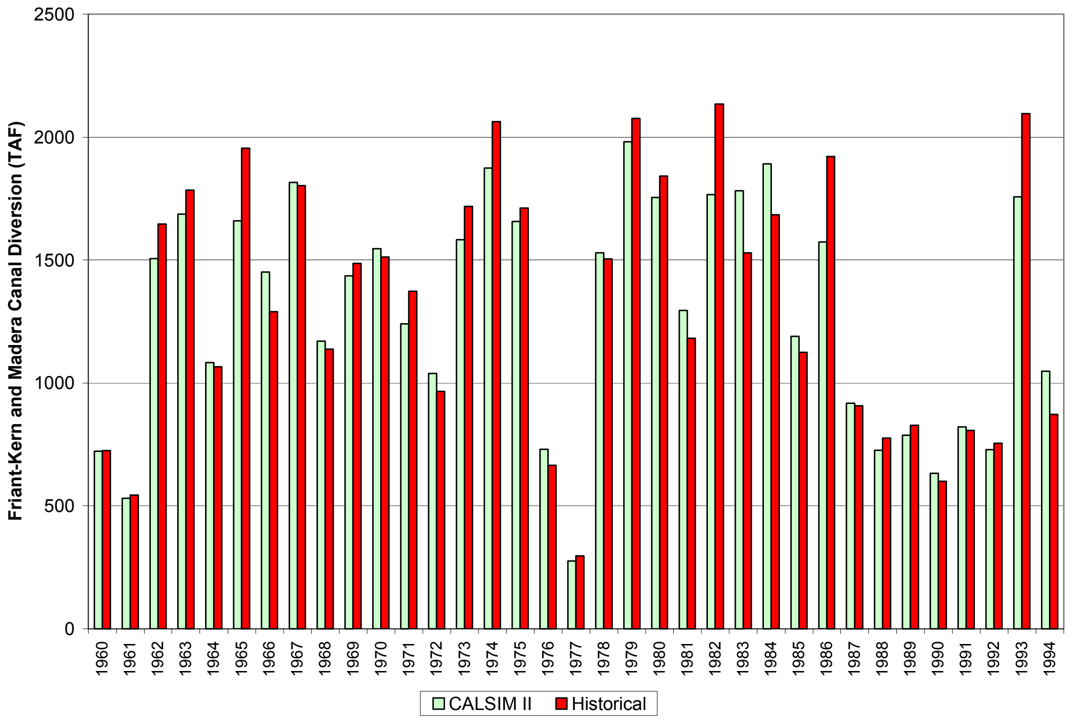

FIGURE A-5. ANNUAL TOTAL CANAL DELIVERY

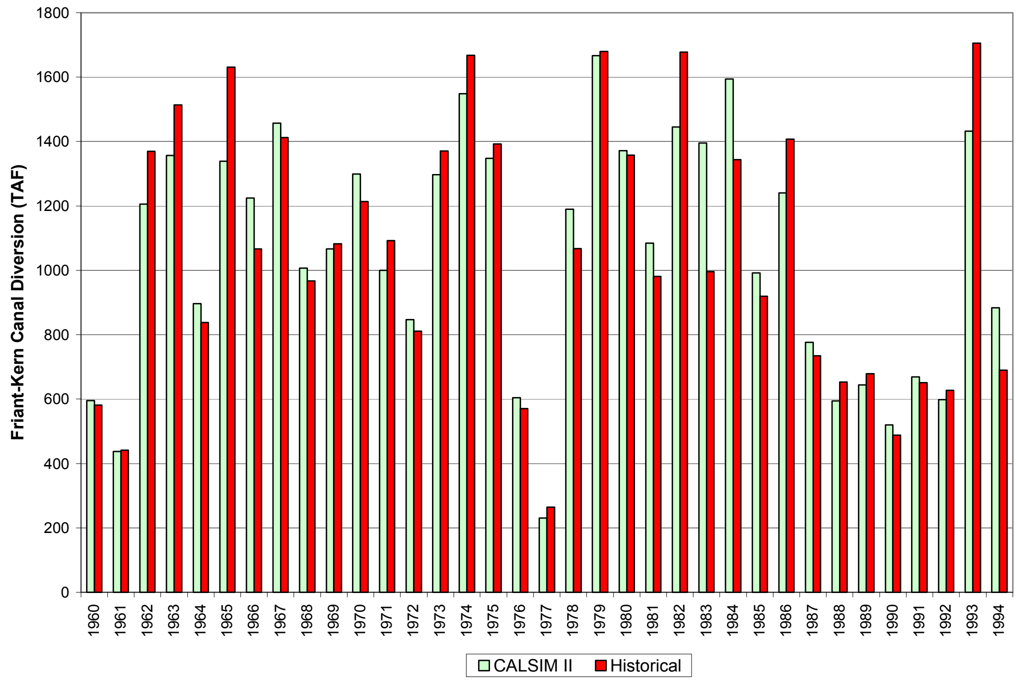

FIGURE A-6. ANNUAL FRIANT-KERN CANAL DELIVERY

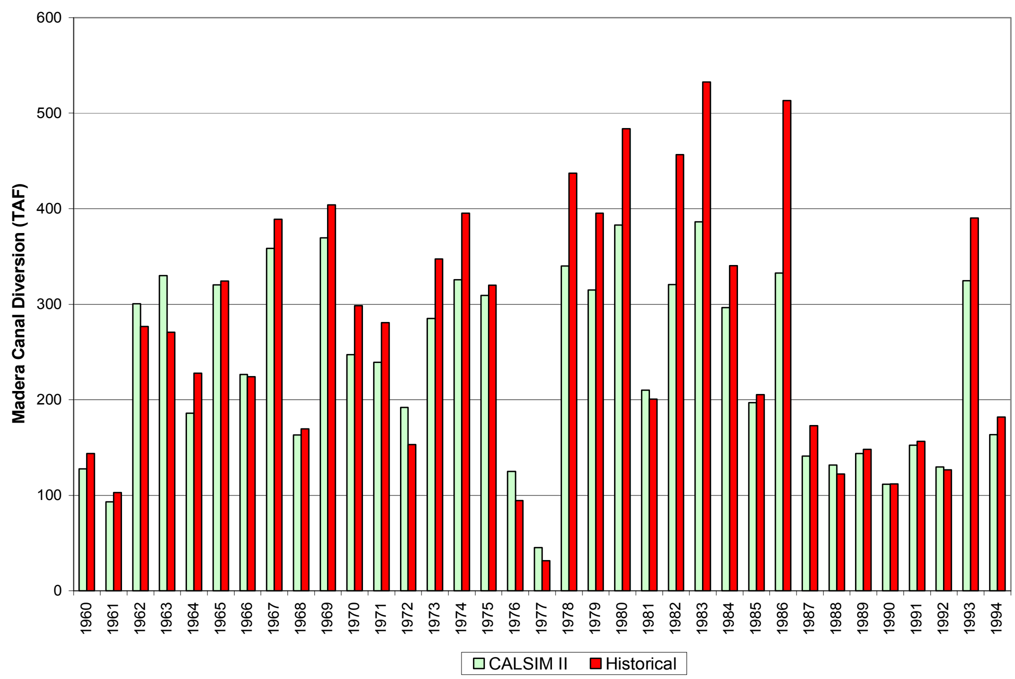

FIGURE A-7. ANNUAL MADERA CANAL DELIVERY

A second component of comparison is the annual river release from Friant Dam. Figure A.8 depicts the modeled and historical annual release to the San Joaquin River.

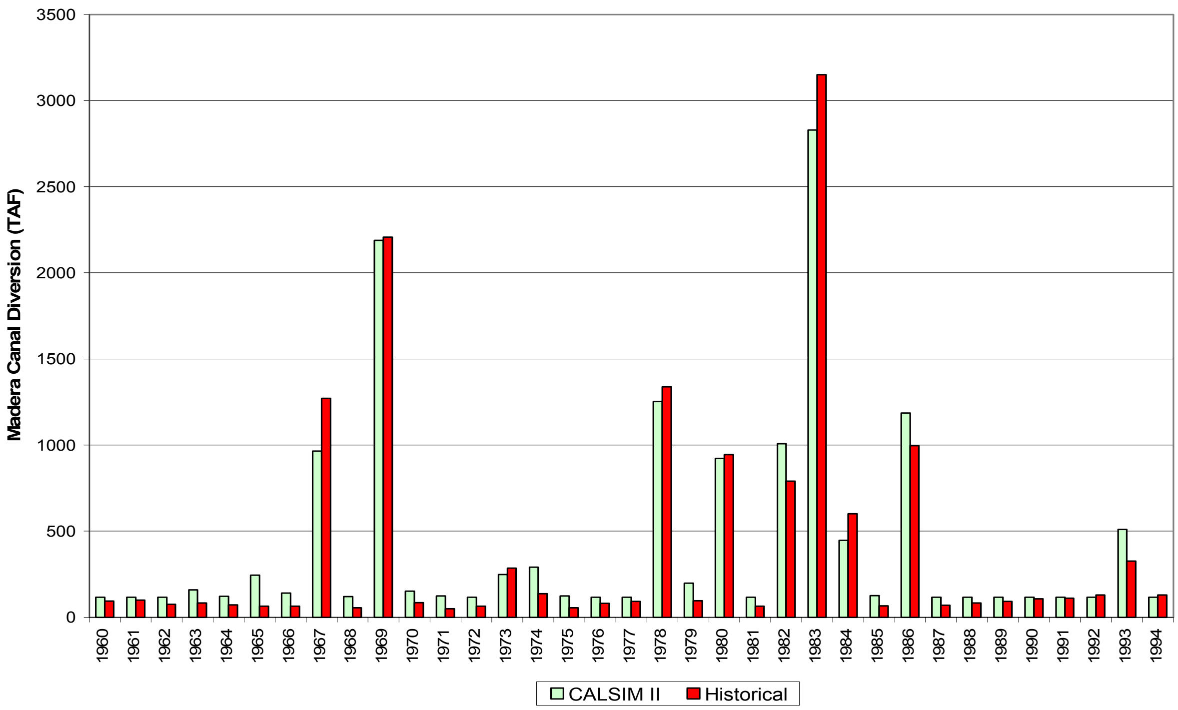

FIGURE A-8. ANNUAL RELEASE TO SAN JOAQUIN RIVER

While at times there occur noticeable differences between historical and simulated annual delivery and river release volumes, the differences are reconciled in many instances and are largely due to the inability of the model to reflect discretionary and intermittent actions, such as flood management and canal maintenance.

The simulation of monthly operations for the entire 1922-1994 hydrologic period is shown in Attachment A.6. Illustrated are Millerton Lake storage, river releases, and canal releases. Also shown is a trace of historical operations since the beginning of Friant Division operations.

ATTACHMENTS

Attachment A.1
Upper San Joaquin Simulation Model Results used in CALSIM

Simulated Millerton Lake Inflow (USAN)

Simulated Mammoth Pool Storage (USAN)

Attachment A.2
Conditional Space Release Matrices

Attachment A.3
Historical River Releases

Attachment A.4
Historical Delivery Data

Attachment A.5
Water Delivery Pattern Matrices

Attachment A.6
Monthly Simulation Results

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Attachment A.1

Upper San Joaquin Simulation Model Results used in CALSIM

Simulated Millerton Lake Inflow (USAN)

Simulated Mammoth Pool Storage (USAN)

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TABLE A.1-1
MODELED MILLERTON INFLOW (1,000 ACRE-FEET)

Modeled Millerton Inflow (1,000 acre-feet)
USAN Base Plan - USBR October 2000

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	WY Total
1922	66	51	82	90	114	108	181	406	660	306	127	103	2294
1923	76	68	109	95	97	123	219	266	213	195	127	115	1703
1924	82	63	41	40	44	81	73	52	5	37	52	70	641
1925	31	37	39	40	90	80	188	208	201	155	106	89	1263
1926	74	55	47	42	75	99	232	242	129	58	77	98	1226
1927	50	74	74	66	158	141	230	297	377	207	112	98	1885
1928	80	114	67	59	72	154	163	206	135	81	111	100	1341
1929	31	29	34	34	38	62	79	156	119	112	85	97	878
1930	28	22	25	34	48	69	128	81	149	94	83	98	859
1931	34	30	27	32	37	40	77	59	18	39	46	69	507
1932	28	15	71	79	171	128	209	245	398	259	115	97	1815
1933	73	61	41	51	54	95	124	57	259	186	124	110	1237
1934	49	32	59	66	65	121	135	44	20	51	69	70	782
1935	39	40	50	81	93	84	251	322	385	158	101	98	1703
1936	77	68	44	64	204	186	265	351	253	159	109	98	1878
1937	66	60	61	59	236	231	269	442	401	173	87	87	2172
1938	76	65	214	122	225	328	421	595	863	433	219	107	3666
1939	91	64	55	75	83	153	218	105	66	70	83	99	1164
1940	60	30	27	141	133	180	233	334	278	111	81	91	1701
1941	64	59	113	136	199	213	248	414	556	347	159	100	2608
1942	84	70	116	148	137	153	267	267	489	300	131	95	2256
1943	77	91	70	153	178	255	280	344	251	170	118	102	2090
1944	67	63	46	55	74	111	114	200	205	166	126	106	1334
1945	63	83	80	66	242	146	216	295	356	254	138	110	2051
1946	110	119	149	108	76	133	236	304	208	128	96	102	1769
1947	81	107	110	72	82	128	134	199	98	74	98	104	1289
1948	45	36	33	35	35	33	129	176	235	134	87	99	1077
1949	63	41	40	40	46	71	170	218	203	83	101	105	1181
1950	63	44	42	64	105	78	208	205	190	106	89	102	1295
1951	70	191	313	217	135	119	170	141	178	146	125	106	1909
1952	57	42	90	163	114	151	287	571	591	334	195	110	2705
1953	73	50	67	122	83	108	146	103	169	211	132	108	1372
1954	51	38	39	53	79	109	206	253	164	100	82	80	1255
1955	61	50	56	63	68	83	99	144	247	123	121	106	1221
1956	48	35	319	284	224	226	251	327	505	306	182	112	2818
1957	92	67	47	61	92	103	115	157	291	168	120	105	1417
1958	69	50	68	64	125	170	285	541	561	313	176	117	2538
1959	77	51	41	71	117	168	171	103	98	71	79	123	1171
1960	49	26	26	33	66	73	140	105	92	72	78	77	837
1961	31	38	48	34	44	46	97	55	55	54	79	71	652
1962	37	29	38	37	183	87	264	270	335	213	115	103	1711
1963	79	63	38	63	243	142	197	229	365	269	149	118	1955
1964	83	109	69	56	54	94	94	117	134	91	119	100	1121
1965	31	50	148	248	141	104	192	237	318	264	216	122	2072
1966	77	140	101	88	77	144	224	204	116	74	100	106	1453
1967	37	46	232	101	121	181	233	391	720	596	246	141	3044
1968	83	51	61	77	109	137	126	117	87	74	85	94	1101
1969	38	55	67	258	245	237	410	836	848	466	228	104	3793
1970	86	61	73	186	119	176	142	166	222	139	129	106	1604
1971	52	58	96	92	88	92	147	144	199	158	138	115	1380
1972	65	53	81	63	68	150	92	126	141	81	107	131	1159
1973	44	49	64	94	131	110	190	424	393	147	96	93	1835
1974	84	130	118	165	91	218	262	354	388	170	123	99	2201
1975	80	70	60	63	97	150	136	279	473	185	107	110	1809
1976	105	83	53	44	59	117	63	56	20	58	80	102	840
1977	46	23	21	25	26	21	45	10	29	38	36	62	383
1978	25	15	86	166	198	241	263	492	725	464	242	216	3133
1979	90	59	59	131	134	209	250	337	283	126	104	102	1883
1980	80	77	57	261	274	260	290	385	499	425	211	114	2932
1981	87	60	55	69	87	130	151	191	137	82	114	109	1272
1982	44	88	82	132	177	219	454	547	529	347	238	187	3046
1983	225	185	221	241	264	376	313	531	1119	687	332	195	4688
1984	106	176	208	200	142	192	215	244	209	164	150	126	2133
1985	81	90	68	63	74	106	197	187	109	79	97	115	1266
1986	50	56	86	106	325	393	349	463	518	245	133	107	2831
1987	90	59	41	52	69	120	130	125	71	64	76	88	984
1988	42	40	41	71	58	79	119	88	82	79	81	83	865
1989	31	28	36	37	49	111	194	120	86	71	79	89	931
1990	50	38	34	40	46	76	136	53	55	80	76	70	754
1991	32	20	24	24	24	99	103	121	199	126	95	110	978
1992	42	39	38	40	80	80	156	120	32	73	76	78	855
1993	35	33	47	195	131	185	247	472	518	323	153	104	2443
1994	82	56	48	57	72	129	118	130	106	67	87	98	1050
1995	67	60	65	216	131	324	330	465	762	752	306	157	3635
1996	78	44	73	108	237	258	281	402	358	184	123	104	2248
1997	74	137	224	606	244	260	277	404	258	137	104	107	2831
1998	73	71	62	122	227	203	267	272	704	673	251	148	3073
1999	91	68	77	105	144	135	164	215	262	129	113	105	1608
Average	66	63	79	103	121	147	198	255	296	192	125	106	1749

TABLE A.1-2
MODELED MAMMOTH POOL INFLOW (1,000 ACRE-FEET)

Modeled Mammoth Pool Storage (Acre-feet)
USAN Base Plan - USBR October 2000

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1922	32296	29247	27737	23500	21433	22899	45153	123000	123000	90744	61712	36116
1923	32896	30658	28743	26572	24011	20207	24789	123000	121841	87420	60972	36342
1924	32583	29516	26528	23521	20834	10726	16641	67041	82982	59070	35242	12213
1925	17429	17082	16287	13897	13196	18956	27198	116023	120087	87006	60880	36045
1926	32305	29130	25928	22818	20558	16134	89576	123000	105020	78957	53581	29173
1927	27410	26240	22286	19592	24372	22896	60172	123000	121351	87462	60919	36071
1928	33332	30863	28033	25628	23302	32568	28850	92353	92076	66578	41613	17631
1929	20244	18420	16641	14709	13062	11843	21698	74287	94171	64233	39356	15478
1930	17805	16875	15193	13684	12678	12703	21334	74481	89719	63938	39261	15508
1931	18594	17039	15214	13744	12265	10876	17809	68101	84370	60270	36461	13240
1932	16168	16975	23280	14863	14270	23967	29596	123000	123000	86653	60119	35288
1933	32835	30340	27921	25756	23408	14702	22526	102367	118466	78213	52542	28123
1934	26806	24038	21683	19022	17179	13156	17699	65733	85319	61013	36951	13659
1935	18699	17314	15558	14535	12993	23708	96208	123000	121829	87061	60978	36102
1936	32865	30427	27997	25638	31604	24170	97578	123000	121359	86761	60052	35184
1937	32692	29880	28074	25157	47725	23735	63964	123000	123000	87135	60831	36019
1938	32821	30381	42553	26377	25387	121411	123000	123000	123000	122492	62071	36602
1939	33545	30630	28070	25852	23510	12605	25634	73962	88055	63625	38602	15161
1940	18799	16989	15270	15029	25356	34814	65167	123000	115645	85877	59917	35154
1941	32588	29744	33875	25326	24114	23533	32818	123000	123000	103820	61150	36110
1942	33078	30975	32144	27180	24074	23034	61646	123000	123000	96090	61018	36080
1943	32831	30802	28532	58084	24642	54317	109619	123000	116226	87566	60910	36090
1944	32585	29933	27221	24758	23183	16856	23110	110741	112689	83561	57611	32938
1945	30533	27901	24883	21394	23644	23106	74925	123000	123000	87585	60968	36112
1946	38999	31014	29677	25893	23795	22990	84184	123000	114006	87005	60889	36114
1947	32423	30221	27141	23642	21307	12534	22772	75024	89538	64187	39501	15721
1948	19089	17049	15304	13669	12270	16754	23048	118241	121665	85845	59965	35277
1949	32036	28737	25544	22250	19650	15804	49125	123000	110985	84611	58766	34144
1950	30616	27773	24403	21546	19582	17875	62063	123000	113919	86525	60775	35999
1951	32658	93498	89393	23412	20157	15846	23319	106344	115127	79372	53748	29265
1952	27703	25047	33373	20691	18049	29995	112893	123000	123000	119705	60298	35414
1953	32819	30370	28885	26152	23707	15088	41437	84539	121885	78346	52479	28101
1954	26707	24132	21448	18957	17273	17969	64646	123000	113542	86903	60738	35992
1955	31912	28812	25666	22612	19832	15264	21881	108446	109845	77931	52481	28081
1956	26578	24201	123000	122284	68230	28216	53012	123000	123000	120999	60506	35543
1957	33226	30503	28025	25596	24599	16740	23850	100307	123000	86064	60128	35421
1958	31818	28530	25265	22443	21493	33070	103849	123000	123000	99073	61277	36342
1959	32890	30439	27870	25472	24357	12192	22988	72799	88089	63247	38563	15302
1960	18551	16902	15256	13733	12476	12127	20370	75323	87237	62655	37782	14185
1961	18584	17198	15393	13835	12308	11386	18128	70098	85825	61418	37291	13979
1962	18616	17236	15445	13830	16649	23321	107286	123000	123000	87521	60999	36165
1963	32852	30237	27659	57522	41120	22095	24326	123000	123000	97263	61045	35913
1964	32975	30537	27662	25033	22403	11922	21613	75986	88472	62929	38421	14598
1965	18668	17338	67799	28439	14190	21873	54410	123000	123000	97984	61401	36246
1966	32768	31230	29859	25429	23009	16750	40271	98675	98290	72413	47026	23206
1967	23279	22344	19326	23299	15641	54476	62957	123000	123000	123000	61813	36687
1968	32860	31214	28119	25809	24548	12874	22266	74390	86642	62302	37383	13825
1969	18489	17064	15916	122591	119026	110770	123000	123000	123000	121953	61448	36431
1970	33156	30656	28256	26934	25121	15773	21717	118583	109749	78805	53006	28589
1971	27045	25192	22315	20076	17353	18124	22824	88535	121216	84778	58359	33455
1972	30458	27428	24871	21608	18943	11551	22279	77257	88528	63005	38421	14503
1973	18603	17373	15682	14226	16838	22318	53961	123000	123000	86875	60854	35960
1974	33004	31005	29376	26602	23702	26101	47357	123000	121435	88452	60629	36154
1975	33089	30558	28051	25575	24195	21083	23551	123000	119811	86884	60916	36352
1976	33407	30337	27522	24789	23211	11372	16718	69639	83623	60427	35587	12565
1977	18529	16915	15344	13641	12168	10479	14511	52722	83541	59230	35654	12649
1978	15267	16957	16705	14493	14207	70310	123000	123000	123000	123000	61503	36353
1979	33066	30768	28113	26541	24653	27964	36959	123000	114436	87039	60927	36240
1980	32731	30019	29499	90612	107566	92995	123000	123000	123000	122989	60486	35659
1981	32948	30488	28023	25884	23635	12666	37228	81732	93291	67817	42785	18597
1982	20670	19124	18167	15956	38744	32797	123000	123000	123000	122921	62066	72937
1983	43761	38339	52416	58078	73382	123000	123000	123000	123000	123000	99782	37830
1984	33625	33197	63629	26604	24437	19305	22950	123000	114752	87080	60327	35349
1985	32764	29913	26288	22939	20929	12991	31719	77055	93677	68450	43401	19380
1986	20996	19922	18554	17545	123000	123000	123000	123000	123000	87693	61229	36664
1987	32994	30400	27886	25370	23155	11565	24030	71730	87483	62541	38140	14738
1988	18985	17032	15526	14151	14047	12253	20238	73489	87034	62136	37643	13913
1989	17568	17296	15469	13838	12708	13002	24197	72610	88898	63698	39071	15891
1990	18683	17185	15388	13716	12815	12031	19687	70604	86890	62013	37818	14354
1991	18284	16974	15256	13616	12579	13974	23475	88491	101136	72007	46550	22699
1992	23111	20845	18619	16216	15363	12212	28623	73203	86575	61977	37543	14073
1993	19118	17089	15721	14851	14067	48815	101580	123000	123000	100645	61291	35974
1994	32766	30885	27910	25393	23819	11969	19904	76819	88198	62993	38664	15362
1995	18899	17737	15889	16739	14262	123000	123000	123000	123000	123000	85680	36351
1996	33266	30472	28595	27864	36269	25214	79222	123000	115325	86708	60206	35216
1997	32922	30540	41505	123000	91093	78172	115575	123000	116008	87170	60926	36280
1998	32674	30112	27101	24835	23219	51244	80718	123000	123000	122845	62118	36631
1999	33129	31715	28480	26669	24078	18330	25140	123000	118036	86911	61252	36235

Attachment A.2

Conditional Space Release Matrices

TABLE A.2-1
FEBRUARY FORECASTED SPILL TABLE

Forecast Spill (TAF)	Percent of spill volume release each month											
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	TOTAL
0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
100	0.0	0.0	0.0	50.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
200	0.0	0.0	33.3	33.3	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
300	0.0	25.0	25.0	25.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
400	20.0	20.0	20.0	20.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
500	16.7	16.7	16.7	16.7	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
600	14.3	14.3	14.3	28.6	28.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
700	12.5	12.5	25.0	25.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
800	11.1	22.2	22.2	22.2	22.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
900	20.0	20.0	20.0	20.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
1000	18.2	18.2	18.2	18.2	27.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
1100	16.7	16.7	16.7	25.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
1200	15.4	15.4	23.1	23.1	23.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
1300	14.3	21.4	21.4	21.4	21.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
1400	20.0	20.0	20.0	20.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
1500	20.0	20.0	20.0	20.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0

TABLE A.2-2
MARCH FORECASTED SPILL TABLE

Forecast Spill (TAF)	Percent of spill volume release each month										
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	TOTAL
0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
100	0.0	0.0	50.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
200	0.0	33.3	33.3	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
300	25.0	25.0	25.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
400	25.0	25.0	25.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
400	20.0	20.0	20.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
500	16.7	16.7	33.3	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
600	14.3	28.6	28.6	28.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
700	25.0	25.0	25.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
800	22.2	22.2	22.2	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
900	20.0	20.0	30.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
1000	18.2	27.3	27.3	27.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
1100	25.0	25.0	25.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
1200	23.1	23.1	23.1	30.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
1300	21.4	21.4	28.6	28.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
1400	21.4	21.4	28.6	28.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0

TABLE A.2-3
APRIL FORECASTED SPILL TABLE

Forecast Spill (TAF)	Percent of spill volume release each month									
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	TOTAL
0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
100	0.0	50.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
200	33.3	33.3	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
300	25.0	25.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
400	20.0	40.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
500	33.3	33.3	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
600	28.6	28.6	42.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
700	25.0	37.5	37.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
800	33.3	33.3	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
900	30.0	30.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
1000	27.3	36.4	36.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
1100	27.3	36.4	36.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0

TABLE A.2-4
MAY FORECASTED SPILL TABLE

Forecast Spill (TAF)	Percent of spill volume release each month									
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	TOTAL
0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
100	50.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
200	33.3	66.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
300	50.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
400	40.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
500	50.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
600	42.9	57.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
700	50.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
800	50.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0

Attachment A.3

Historical River Releases

TABLE A.3-1
HISTORICAL RIVER RELEASE (1,000 ACRE-FEET)

Historical River Release (1,000 acre-feet)
USBR Report of Operations

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1981	4.8	4.3	2.2	3.1	2.6	2.5	4.9	6.2	7.7	11.0	8.5	7.5	65.2
1982	6.2	5.5	3.4	2.7	2.0	8.6	409.0	231.3	88.6	22.4	6.1	4.6	790.5
1983	4.2	92.2	228.1	222.5	281.4	437.4	465.9	379.9	526.9	311.1	81.5	118.9	3,150.0
1984	73.1	75.8	133.0	241.0	22.0	5.0	12.7	6.2	7.7	9.2	8.4	6.9	601.0
1985	5.6	3.1	1.8	1.9	1.7	2.8	6.6	8.0	9.1	9.9	8.7	7.8	67.0
1986	6.6	4.1	3.3	3.5	201.0	416.1	288.2	17.2	31.8	9.6	8.4	7.4	997.1
1987	4.2	4.5	2.4	2.2	2.5	2.1	7.9	8.0	8.6	10.2	9.2	7.8	69.7
1988	7.1	4.0	3.7	3.1	3.6	6.7	6.0	8.0	9.4	11.6	11.3	9.1	83.6
1989	8.3	6.1	3.5	2.1	4.1	5.7	7.7	9.1	10.3	12.6	12.6	9.5	91.7
1990	7.9	6.5	6.3	3.3	4.5	7.1	9.9	11.6	11.9	14.0	13.7	10.8	107.5
1991	9.5	7.9	6.8	6.7	8.0	4.8	7.4	10.6	11.9	13.6	12.9	10.6	110.7
1992	10.0	7.6	6.7	5.3	4.5	6.7	9.2	13.1	16.5	16.8	17.8	15.4	129.6
1993	12.9	7.8	7.3	3.0	2.0	26.5	72.2	56.7	63.5	42.0	18.1	15.3	327.1
1994	10.3	7.5	6.4	6.8	6.3	9.5	10.0	10.5	13.0	16.6	16.4	14.8	128.2
1995	11.1	8.4	6.8	2.9	20.8	228.0	340.8	451.7	156.6	324.2	28.8	11.8	1,591.9
1996	10.3	8.4	5.4	4.7	35.0	97.4	68.2	99.7	20.3	14.6	13.9	12.3	390.1
1997	10.7	6.7	63.5	544.5	353.5	80.2	13.9	17.4	17.3	18.6	20.6	18.3	1,165.3
1998	15.7	12.2	10.8	6.2	173.7	146.1	272.7	252.0	392.8	270.3	25.1	25.5	1,603.0
1999	23.9	24.4	34.9	17.1	28.1	5.1	5.9	9.2	24.7	35.2	19.6	13.8	241.8
2000	9.6	6.0	5.2	5.3	2.9	53.9	8.0	7.8	27.7	14.1	14.9	14.5	169.8

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Attachment A.4

Historical Delivery Data

TABLE A.4-1
FRIANT-KERN CANAL

Fri

Data used in development of delivery distribution curves

Used in development of Class 1 only supply curves

Used in development of full Class 1 and full Class 2 curves

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Class 1 (Absolute Delivery TAF)

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	4	20	87	176	85	59	29	9	12	16	497	100/100
1983-84	0	0	2	6	69	147	119	66	55	3	0	152	619	100/100
1984-85	5	27	60	123	171	76	45	43	27	1	0	83	661	100/50
1985-86	78	77	99	135	132	69	17	18	4	1	3	18	651	100/14
1986-87	0	4	11	28	124	132	128	71	33	24	16	69	640	100/100
1987-88	26	62	49	84	110	85	53	39	3	2	6	101	620	91/0
1988-89	44	22	48	101	133	71	38	27	9	0	0	13	506	78/0
1989-90	33	68	61	122	155	89	42	32	19	4	2	11	638	98/0
1990-91	50	28	34	52	88	92	46	31	15	0	0	8	444	68/0
1991-92	1	14	60	122	175	107	58	57	17	1	0	7	619	100/0
1992-93	21	40	66	144	100	97	42	28	9	0	0	53	600	83/0
1993-94	0	1	13	58	173	165	79	48	21	6	12	16	592	100/90
1994-95	25	34	35	129	147	97	47	19	5	1	4	38	581	80/0
1995-96	0	1	2	9	51	75	85	61	36	15	2	34	371	100/100
1996-97	0	3	16	106	227	133	67	55	7	1	0	0	615	100/58
1997-98	2	6	34	108	178	125	67	46	22	10	6	8	612	100/60

Class 1 (Montly Distribution % of Annual)

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	75 Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	1	4	18	35	17	12	6	2	2	3	100	100/100
1983-84	0	0	0	1	11	24	19	11	9	0	0	25	100	100/100
1984-85	1	4	9	19	26	11	7	7	4	0	0	13	100	100/50
1985-86	12	12	15	21	20	11	3	3	1	0	0	3	100	100/14
1986-87	0	1	2	4	19	21	20	11	5	4	3	11	100	100/100
1987-88	4	10	8	14	18	14	9	6	0	0	1	16	100	91/0
1988-89	9	4	9	20	26	14	8	5	2	0	0	3	100	78/0
1989-90	5	11	10	19	24	14	7	5	3	1	0	2	100	98/0
1990-91	11	6	8	12	20	21	10	7	3	0	0	2	100	68/0
1991-92	0	2	10	20	28	17	9	9	3	0	0	1	100	100/0
1992-93	4	7	11	24	17	16	7	5	2	0	0	9	100	83/0
1993-94	0	0	2	10	29	28	13	8	4	1	2	3	100	100/90
1994-95	4	6	6	22	25	17	8	3	1	0	1	7	100	80/0
1995-96	0	0	1	2	14	20	23	16	10	4	1	9	100	100/100
1996-97	0	0	3	17	37	22	11	9	1	0	0	0	100	100/58
1997-98	0	1	6	18	29	20	11	8	4	2	1	1	100	100/60
Avg	5	6	9	20	26	15	8	6	2	0	0	3	100	
Avg	0	0	2	7	24	24	17	10	4	2	2	7	100	

Class 2 (Absolute Delivery TAF)

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	111	71	118	230	174	75	14	1	0	0	0	0	794	100/100
1983-84	3	50	108	156	154	21	0	0	0	0	0	0	492	100/100
1984-85	98	48	57	83	52	82	52	31	1	2	0	13	519	100/50
1985-86	0	0	0	6	3	15	35	31	2	0	3	36	131	100/14
1986-87	42	108	181	215	118	69	33	3	0	0	0	0	769	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	1	1	0	0	2	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	1	2	0	0	3	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	2	2	0	2	6	83/0
1993-94	171	141	218	198	100	71	17	18	0	0	0	0	934	100/90
1994-95	1	1	1	2	2	1	1	1	0	0	0	24	34	80/0
1995-96	50	67	47	90	150	168	58	36	26	13	20	12	737	100/100
1996-97	54	123	153	130	26	51	21	0	0	0	0	0	558	100/58
1997-98	95	146	103	112	52	29	20	26	2	2	0	0	587	100/60

Other (Absolute Delivery TAF)

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	24	89	0	0	0	0	0	0	0	0	0	113	100/100
1983-84	0	0	0	0	3	0	0	0	0	0	0	0	3	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	0	0	100/14
1986-87	9	4	2	2	0	0	0	0	0	0	0	0	17	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	80	25	8	9	0	0	0	0	0	0	0	122	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	22	22	80/0
1995-96	20	8	77	141	32	1	0	0	0	0	0	0	279	100/100
1996-97	19	44	49	20	0	0	0	0	0	0	13	18	163	100/58
1997-98	5	0	0	0	0	0	0	0	0	0	0	13	18	100/60

TABLE A.4-2
FRIANT-KERN CANAL

Fr... Canal

Total (Absolute Delivery TAF)

Data used in development of delivery distribution curves

Used in development of Class 1 only supply curves

Used in development of full Class 1 and full Class 2 curves

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	111	95	211	250	261	251	99	60	29	9	12	16	1404	100/100
1983-84	3	50	110	162	226	168	119	66	55	3	0	152	1114	100/100
1984-85	103	75	117	206	223	158	97	74	28	3	0	96	1180	100/50
1985-86	78	77	99	141	135	84	52	49	6	1	6	54	782	100/14
1986-87	51	116	194	245	242	201	161	74	33	24	16	69	1426	100/100
1987-88	26	62	49	84	110	85	53	39	3	2	6	101	620	91/0
1988-89	44	22	48	101	133	71	38	27	10	1	0	13	508	78/0
1989-90	33	68	61	122	155	89	42	32	19	4	2	11	638	98/0
1990-91	50	28	34	52	88	92	46	31	16	2	0	8	447	68/0
1991-92	1	14	60	122	175	107	58	57	17	1	0	7	619	100/0
1992-93	21	40	66	144	100	97	42	28	11	2	0	55	606	83/0
1993-94	171	222	256	264	282	236	96	66	21	6	12	16	1648	100/90
1994-95	26	35	36	131	149	98	48	20	5	1	4	84	637	80/0
1995-96	70	76	126	240	233	244	143	97	62	28	22	46	1387	100/100
1996-97	73	170	218	256	253	184	88	55	7	1	13	18	1336	100/58
1997-98	102	152	137	220	230	154	87	72	24	12	6	21	1217	100/60

Total (Percentage of Annual Total)

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	8	7	15	18	19	18	7	4	2	1	1	1	100	100/100
1983-84	0	4	10	15	20	15	11	6	5	0	0	14	100	100/100
1984-85	9	6	10	17	19	13	8	6	2	0	0	8	100	100/50
1985-86	10	10	13	18	17	11	7	6	1	0	1	7	100	100/14
1986-87	4	8	14	17	17	14	11	5	2	2	1	5	100	100/100
1987-88	4	10	8	14	18	14	9	6	0	0	1	16	100	91/0
1988-89	9	4	9	20	26	14	7	5	2	0	0	3	100	78/0
1989-90	5	11	10	19	24	14	7	5	3	1	0	2	100	98/0
1990-91	11	6	8	12	20	21	10	7	4	0	0	2	100	68/0
1991-92	0	2	10	20	28	17	9	9	3	0	0	1	100	100/0
1992-93	3	7	11	24	17	16	7	5	2	0	0	9	100	83/0
1993-94	10	13	16	16	17	14	6	4	1	0	1	1	100	100/90
1994-95	4	5	6	21	23	15	8	3	1	0	1	13	100	80/0
1995-96	5	5	9	17	17	18	10	7	4	2	2	3	100	100/100
1996-97	5	13	16	19	19	14	7	4	1	0	1	1	100	100/58
1997-98	8	12	11	18	19	13	7	6	2	1	0	2	100	100/60
Avg	5	6	9	20	26	15	8	6	2	0	0	5	100	
Avg	7	11	15	17	17	14	9	5	2	1	1	3	100	

TABLE A.4-3
MADERA CANAL

Madera Canal

Class 1 (Absolute Delivery TAF)

Data used in development of delivery distribution curves

Used in development of Class 1 only supply curves

Used in development of full Class 1 and full Class 2 curves

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	48	39	28	2	0	0	11	128	100/100
1983-84	0	0	0	0	4	44	30	15	0	0	0	6	99	100/100
1984-85	0	0	10	32	43	29	13	0	0	0	0	13	140	100/50
1985-86	41	2	3	25	35	28	6	0	0	0	0	0	140	100/14
1986-87	0	0	0	0	14	50	39	23	9	0	0	1	136	100/100
1987-88	9	0	0	37	51	29	3	0	0	0	0	0	129	91/0
1988-89	0	0	4	41	54	13	0	0	0	0	0	0	112	78/0
1989-90	0	0	17	43	55	22	1	0	0	0	0	0	138	98/0
1990-91	0	0	0	18	49	32	2	0	0	0	0	0	101	68/0
1991-92	0	0	15	27	57	36	6	0	0	0	0	0	141	100/0
1992-93	0	0	20	49	41	9	0	0	0	0	0	0	119	83/0
1993-94	0	0	0	0	0	12	45	34	5	0	0	0	96	100/90
1994-95	0	0	11	34	42	38	10	0	0	0	0	0	135	80/0
1995-96	0	0	0	0	0	0	10	23	5	0	0	1	39	100/100
1996-97	0	0	0	10	53	35	15	8	0	0	0	0	121	100/58
1997-98	0	0	0	1	47	36	32	18	0	0	0	0	134	100/60

Class 1 (Montly Distribution % of Annual)

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	68 Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	0	0	0	0	38	30	22	2	0	0	9	100	100/100
1983-84	0	0	0	0	4	44	30	15	0	0	0	6	100	100/100
1984-85	0	0	7	23	31	21	9	0	0	0	0	9	100	100/50
1985-86	29	1	2	18	25	20	4	0	0	0	0	0	100	100/14
1986-87	0	0	0	0	10	37	29	17	7	0	0	1	100	100/100
1987-88	7	0	0	29	40	22	2	0	0	0	0	0	100	91/0
1988-89	0	0	4	37	48	12	0	0	0	0	0	0	100	78/0
1989-90	0	0	12	31	40	16	1	0	0	0	0	0	100	98/0
1990-91	0	0	0	18	49	32	2	0	0	0	0	0	100	68/0
1991-92	0	0	11	19	40	26	4	0	0	0	0	0	100	100/0
1992-93	0	0	17	41	34	8	0	0	0	0	0	0	100	83/0
1993-94	0	0	0	0	0	13	47	35	5	0	0	0	100	100/90
1994-95	0	0	8	25	31	28	7	0	0	0	0	0	100	80/0
1995-96	0	0	0	0	0	0	26	59	13	0	0	3	100	100/100
1996-97	0	0	0	8	44	29	12	7	0	0	0	0	100	100/58
1997-98	0	0	0	1	35	27	24	13	0	0	0	0	100	100/60
Avg	0	0	9	28	40	20	3	0	0	0	0	0	100	
Avg	0	0	0	0	5	25	38	26	6	0	0	0	100	

Class 2 (Absolute Delivery TAF)

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	24	23	70	71	71	15	0	0	0	0	0	0	274	100/100
1983-84	16	30	52	66	67	7	0	0	0	0	0	0	238	100/100
1984-85	43	34	23	0	17	21	22	6	0	0	0	1	167	100/50
1985-86	0	0	0	0	0	11	16	4	0	0	0	12	43	100/14
1986-87	28	49	74	72	62	10	0	1	0	0	0	0	296	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	29	49	63	62	74	47	0	0	0	0	0	0	324	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	12	17	21	31	40	61	28	5	0	0	0	0	215	100/100
1996-97	13	42	54	46	0	9	12	0	0	0	0	0	176	100/58
1997-98	38	42	49	58	11	0	0	0	0	0	0	0	198	100/60

Other (Absolute Delivery TAF)

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	0	29	2	0	0	0	0	0	0	0	0	13	44	100/100
1983-84	42	38	18	4	2	8	38	23	0	0	0	0	173	100/100
1984-85	0	0	0	0	0	0	0	0	0	0	0	0	0	100/50
1985-86	0	0	0	0	0	0	0	0	0	0	0	19	19	100/14
1986-87	30	20	1	1	0	0	0	0	0	0	0	0	52	100/100
1987-88	0	0	0	0	0	0	0	0	0	0	0	0	0	91/0
1988-89	0	0	0	0	0	0	0	0	0	0	0	0	0	78/0
1989-90	0	0	0	0	0	0	0	0	0	0	0	0	0	98/0
1990-91	0	0	0	0	0	0	0	0	0	0	0	0	0	68/0
1991-92	0	0	0	0	0	0	0	0	0	0	0	0	0	100/0
1992-93	0	0	0	0	0	0	0	0	0	0	0	0	0	83/0
1993-94	0	1	1	2	2	0	0	0	0	0	0	0	6	100/90
1994-95	0	0	0	0	0	0	0	0	0	0	0	0	0	80/0
1995-96	28	33	41	31	33	3	0	0	0	0	0	0	169	100/100
1996-97	30	0	9	1	0	0	0	0	0	0	34	17	91	100/58
1997-98	12	0	0	0	0	0	0	0	0	0	0	0	12	100/60

TABLE A.4-4
MADERA CANAL

Madera Canal

Total (Absolute Delivery TAF)

Data used in development of delivery distribution curves

Used in development of Class 1 only supply curves

Used in development of full Class 1 and full Class 2 curves

T

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	24	52	72	71	71	63	39	28	2	0	0	24	446	100/100
1983-84	58	68	70	70	73	59	68	38	0	0	0	6	510	100/100
1984-85	43	34	33	32	60	50	35	6	0	0	0	14	307	100/50
1985-86	41	2	3	25	35	39	22	4	0	0	0	31	202	100/14
1986-87	58	69	75	73	76	60	39	24	9	0	0	1	484	100/100
1987-88	9	0	0	37	51	29	3	0	0	0	0	0	129	91/0
1988-89	0	0	4	41	54	13	0	0	0	0	0	0	112	78/0
1989-90	0	0	17	43	55	22	1	0	0	0	0	0	138	98/0
1990-91	0	0	0	18	49	32	2	0	0	0	0	0	101	68/0
1991-92	0	0	15	27	57	36	6	0	0	0	0	0	141	100/0
1992-93	0	0	20	49	41	9	0	0	0	0	0	0	119	83/0
1993-94	29	50	64	64	76	59	45	34	5	0	0	0	426	100/90
1994-95	0	0	11	34	42	38	10	0	0	0	0	0	135	80/0
1995-96	40	50	62	62	73	64	38	28	5	0	0	1	423	100/100
1996-97	43	42	63	57	53	44	27	8	0	0	34	17	388	100/58
1997-98	50	42	49	59	58	36	32	18	0	0	0	0	344	100/60

Total (Percentage of Annual Total)

Mar-Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Yr-Total	Cl1/Cl2
1982-83	5	12	16	16	16	14	9	6	0	0	0	5	100	100/100
1983-84	11	13	14	14	14	12	13	7	0	0	0	1	100	100/100
1984-85	14	11	11	10	20	16	11	2	0	0	0	5	100	100/50
1985-86	20	1	1	12	17	19	11	2	0	0	0	15	100	100/14
1986-87	12	14	15	15	16	12	8	5	2	0	0	0	100	100/100
1987-88	7	0	0	29	40	22	2	0	0	0	0	0	100	91/0
1988-89	0	0	4	37	48	12	0	0	0	0	0	0	100	78/0
1989-90	0	0	12	31	40	16	1	0	0	0	0	0	100	98/0
1990-91	0	0	0	18	49	32	2	0	0	0	0	0	100	68/0
1991-92	0	0	11	19	40	26	4	0	0	0	0	0	100	100/0
1992-93	0	0	17	41	34	8	0	0	0	0	0	0	100	83/0
1993-94	7	12	15	15	18	14	11	8	1	0	0	0	100	100/90
1994-95	0	0	8	25	31	28	7	0	0	0	0	0	100	80/0
1995-96	9	12	15	15	17	15	9	7	1	0	0	0	100	100/100
1996-97	11	11	16	15	14	11	7	2	0	0	9	4	100	100/58
1997-98	15	12	14	17	17	10	9	5	0	0	0	0	100	100/60
Avg	0	0	9	28	40	20	3	0	0	0	0	0	100	
Avg	9	13	15	15	17	13	9	6	2	0	0	0	100	

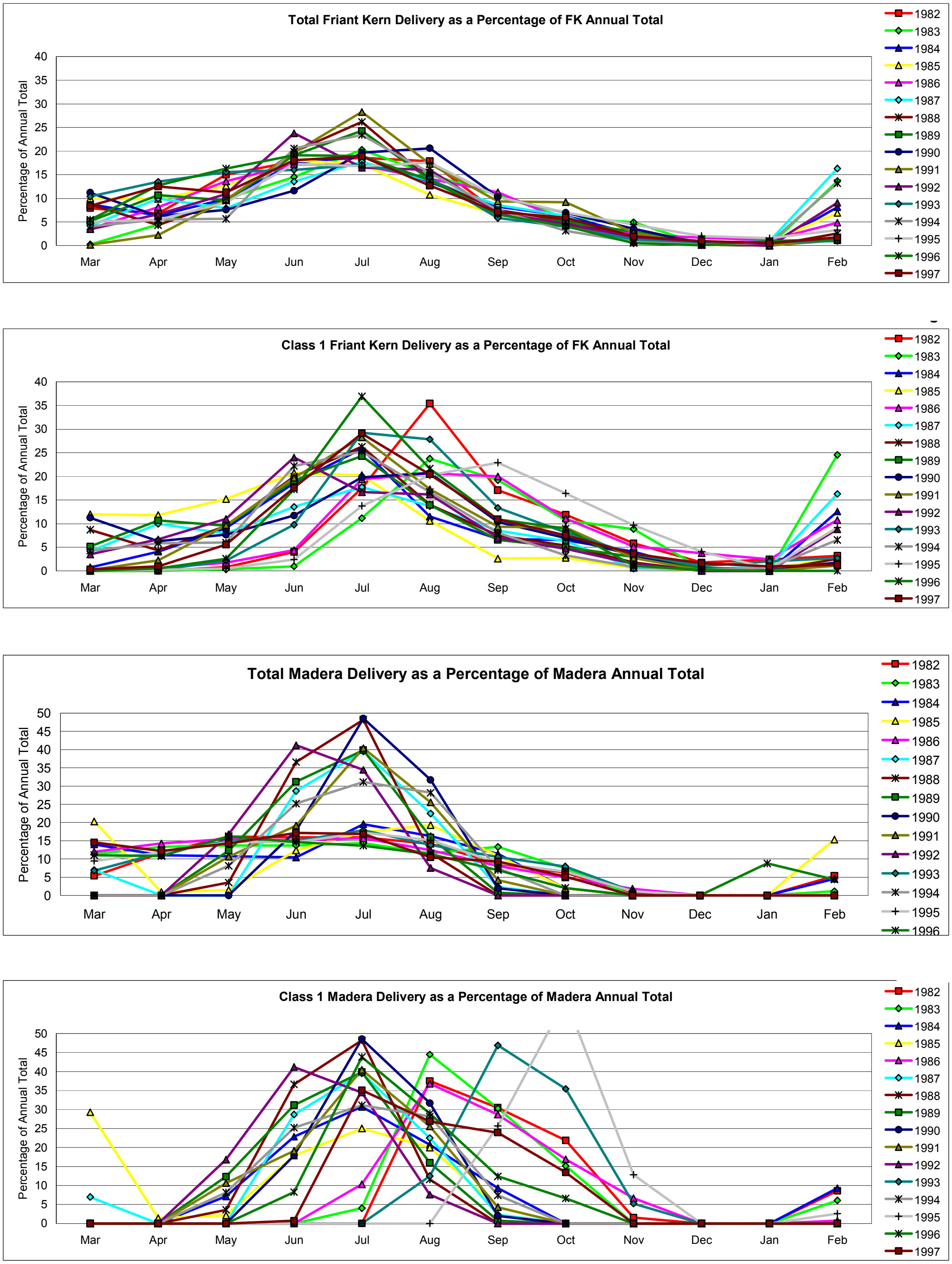

FIGURE A.4-1. MONTHLY WATER DELIVERY PERCENTAGES

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Attachment A.5

Water Delivery Pattern Matrices

TABLE A.5-1
TOTAL FRIANT-KERN CANAL DELIVERY PATTERN

Total Delivery													
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Total
0	5.0	6.0	9.0	20.0	26.0	15.0	8.0	6.0	2.0	0.0	0.0	3.0	100.0
800	6.0	10.0	13.0	16.0	19.0	16.0	9.0	4.0	1.0	1.0	1.0	4.0	100.0
900	6.0	10.0	13.0	16.0	19.0	16.0	9.0	4.0	1.0	1.0	1.0	4.0	100.0
1000	6.0	10.0	13.0	16.0	19.0	16.0	9.0	4.0	1.0	1.0	1.0	4.0	100.0
1100	6.0	10.0	13.0	16.0	19.0	16.0	9.0	4.0	1.0	1.0	1.0	4.0	100.0
1200	6.0	10.0	13.0	16.0	19.0	16.0	9.0	4.0	1.0	1.0	1.0	4.0	100.0
1300	6.0	10.0	13.0	16.0	19.0	16.0	9.0	4.0	1.0	1.0	1.0	4.0	100.0
1400	6.0	10.0	13.0	16.0	19.0	16.0	9.0	4.0	1.0	1.0	1.0	4.0	100.0
1500	5.0	5.0	8.0	15.0	18.1	15.6	9.0	6.0	2.0	2.0	2.0	8.0	95.7
1600	5.0	5.0	8.0	14.0	17.3	15.3	9.0	6.0	2.0	2.0	2.0	8.0	93.6
1700	5.0	5.0	8.0	13.2	16.4	14.9	9.0	6.0	2.0	2.0	2.0	8.0	91.5
1800	5.0	5.0	8.0	12.3	15.5	14.5	9.0	6.0	2.0	2.0	2.0	8.0	89.3
1900	5.0	5.0	8.0	11.5	14.6	14.1	9.0	6.0	2.0	2.0	2.0	8.0	87.2
2000	5.0	5.0	8.0	10.7	13.8	13.8	9.0	6.0	2.0	2.0	2.0	8.0	85.3
2100	5.0	5.0	8.0	9.8	12.9	13.4	9.0	6.0	2.0	2.0	2.0	8.0	83.1
2200	5.0	5.0	8.0	9.0	12.0	13.0	9.0	6.0	2.0	2.0	2.0	8.0	81.0

TABLE A.5-2
TOTAL MADERA CANAL DELIVERY PATTERN

Total Delivery	Percent of annual delivery												
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	
0	0.0	0.0	9.0	28.0	35.0	24.0	4.0	0.0	0.0	0.0	0.0	0.0	100.0
800	0.0	0.0	9.0	28.0	35.0	24.0	4.0	0.0	0.0	0.0	0.0	0.0	100.0
900	0.0	0.0	9.0	28.0	35.0	24.0	4.0	0.0	0.0	0.0	0.0	0.0	100.0
1000	0.0	0.0	9.0	28.0	35.0	24.0	4.0	0.0	0.0	0.0	0.0	0.0	100.0
1100	9.0	10.0	15.0	17.0	21.0	16.0	8.0	1.0	1.0	0.0	0.0	2.0	100.0
1200	9.0	10.0	15.0	17.0	21.0	16.0	8.0	1.0	1.0	0.0	0.0	2.0	100.0
1300	9.0	10.0	15.0	17.0	21.0	16.0	8.0	1.0	1.0	0.0	0.0	2.0	100.0
1400	9.0	10.0	15.0	17.0	21.0	16.0	8.0	1.0	1.0	0.0	0.0	2.0	100.0
1500	9.0	10.0	15.0	17.0	21.0	16.0	8.0	1.0	1.0	0.0	0.0	2.0	100.0
1600	9.0	12.0	14.0	15.0	15.0	14.0	10.0	6.0	1.0	0.0	0.0	4.0	100.0
1700	9.0	12.0	14.0	15.0	15.0	14.0	10.0	6.0	1.0	0.0	0.0	4.0	100.0
1800	9.0	12.0	14.0	15.0	15.0	14.0	10.0	6.0	1.0	0.0	0.0	4.0	100.0
1900	9.0	12.0	14.0	15.0	15.0	14.0	10.0	6.0	1.0	0.0	0.0	4.0	100.0
2000	9.0	12.0	14.0	15.0	15.0	14.0	10.0	6.0	1.0	0.0	0.0	4.0	100.0
2100	9.0	12.0	14.0	15.0	15.0	14.0	10.0	6.0	1.0	0.0	0.0	4.0	100.0
2200	9.0	12.0	14.0	15.0	15.0	14.0	10.0	6.0	1.0	0.0	0.0	4.0	100.0

TABLE A.5-3
FRIANT-KERN CANAL CLASS 1 DELIVERY PATTERN

Total Delivery	Percent of annual delivery												
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	
0	5.0	6.0	9.0	20.0	26.0	15.0	8.0	6.0	2.0	0.0	0.0	3.0	100.0
800	6.0	10.0	13.0	16.0	19.0	16.0	9.0	4.0	1.0	1.0	1.0	4.0	100.0
900	5.6	9.3	12.4	15.8	20.0	16.6	9.4	4.0	1.0	1.0	1.0	4.0	100.1
1000	5.1	8.6	11.7	15.6	20.9	17.1	9.9	4.0	1.0	1.0	1.0	4.0	99.9
1100	4.7	7.9	11.1	15.5	21.9	17.7	10.3	4.0	1.0	1.0	1.0	4.0	100.1
1200	4.3	7.1	10.4	15.3	22.6	18.3	10.7	4.0	1.0	1.0	1.0	4.3	100.0
1300	3.9	6.4	9.8	15.1	21.0	18.9	11.1	5.8	1.7	1.0	1.0	4.4	100.1
1400	3.4	5.7	9.1	14.9	21.4	19.4	11.6	6.1	1.9	1.0	1.0	4.4	99.9
1500	3.0	5.0	8.5	14.8	21.7	20.0	12.0	6.5	2.0	1.0	1.0	4.5	100.0
1600	2.6	4.3	7.9	14.6	22.1	20.6	12.4	6.9	2.1	1.0	1.0	4.6	100.1
1700	2.1	3.6	7.2	14.4	22.5	21.1	12.9	7.2	2.3	1.0	1.0	4.6	99.9
1800	1.7	2.9	6.6	14.2	22.9	21.7	13.3	7.6	2.4	1.0	1.0	4.7	100.0
1900	1.3	2.1	5.9	14.0	23.3	22.3	13.7	7.9	2.6	1.0	1.0	4.8	99.9
2000	0.9	1.4	5.3	13.9	23.7	22.9	14.1	8.3	2.7	1.0	1.0	4.9	100.1
2100	0.4	0.7	4.6	13.7	24.1	23.4	14.6	8.6	2.9	1.0	1.0	4.9	99.9
2200	0.0	0.0	4.0	13.5	24.5	24.0	15.0	9.0	3.0	1.0	1.0	5.0	100.0

TABLE A.5-4
MADERA CANAL CLASS 1 DELIVERY PATTERN

Total Delivery	Percent of annual delivery												
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	
0	0.0	0.0	9.0	28.0	35.0	24.0	4.0	0.0	0.0	0.0	0.0	0.0	100.0
800	0.0	0.0	9.0	28.0	35.0	24.0	4.0	0.0	0.0	0.0	0.0	0.0	100.0
900	0.0	0.0	9.0	28.0	35.0	24.0	4.0	0.0	0.0	0.0	0.0	0.0	100.0
1000	0.0	0.0	9.0	28.0	35.0	24.0	4.0	0.0	0.0	0.0	0.0	0.0	100.0
1100	0.0	0.0	9.0	28.0	35.0	24.0	4.0	0.0	0.0	0.0	0.0	0.0	100.0
1200	0.0	0.0	0.0	24.0	30.0	30.0	14.0	1.0	1.0	0.0	0.0	0.0	100.0
1300	0.0	0.0	0.0	22.0	30.0	30.0	15.0	2.0	1.0	0.0	0.0	0.0	100.0
1400	0.0	0.0	0.0	22.0	30.0	30.0	15.0	2.0	1.0	0.0	0.0	0.0	100.0
1500	0.0	0.0	0.0	20.0	30.0	30.0	15.0	3.0	2.0	0.0	0.0	0.0	100.0
1600	0.0	0.0	0.0	18.0	30.0	30.0	15.0	5.0	2.0	0.0	0.0	0.0	100.0
1700	0.0	0.0	0.0	16.0	30.0	30.0	15.0	7.0	2.0	0.0	0.0	0.0	100.0
1800	0.0	0.0	0.0	8.0	22.0	30.0	24.0	10.0	3.0	0.0	0.0	3.0	100.0
1900	0.0	0.0	0.0	8.0	17.0	30.0	24.0	15.0	3.0	0.0	0.0	3.0	100.0
2000	0.0	0.0	0.0	8.0	17.0	30.0	24.0	15.0	3.0	0.0	0.0	3.0	100.0
2100	0.0	0.0	0.0	8.0	17.0	30.0	24.0	15.0	3.0	0.0	0.0	3.0	100.0
2200	0.0	0.0	0.0	8.0	17.0	30.0	24.0	15.0	3.0	0.0	0.0	3.0	100.0

Attachment A.6

Monthly Simulation Results

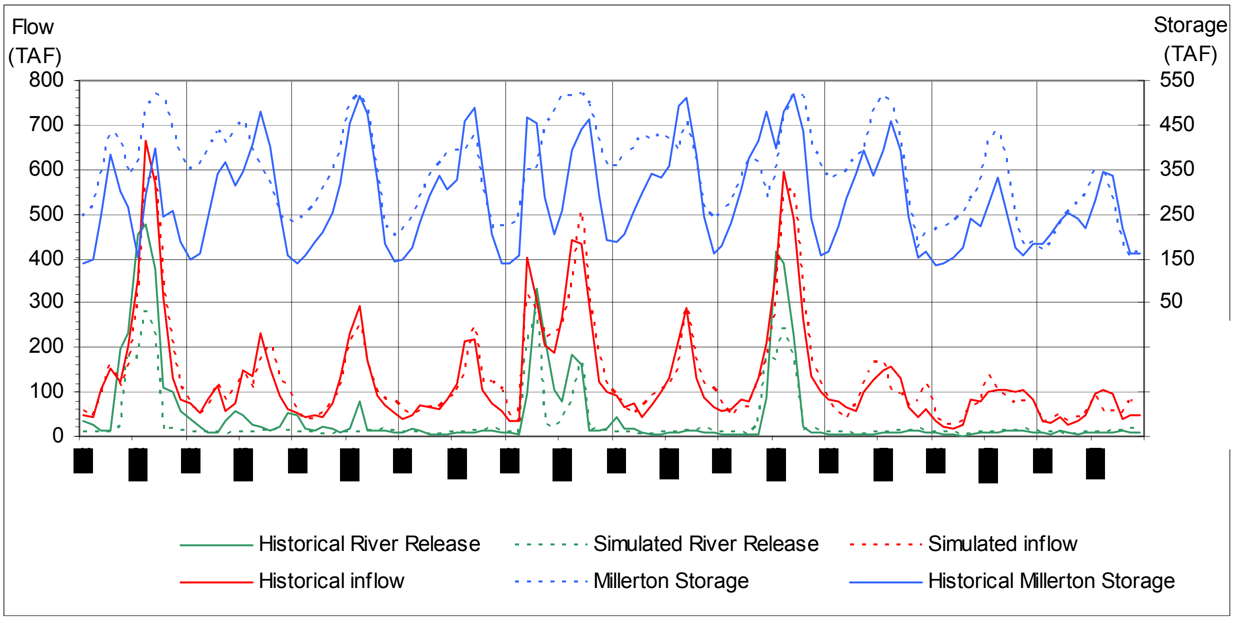

FIGURE A.6-1. SIMULATION OF MILLERTON RESEVOIR 1952-1961

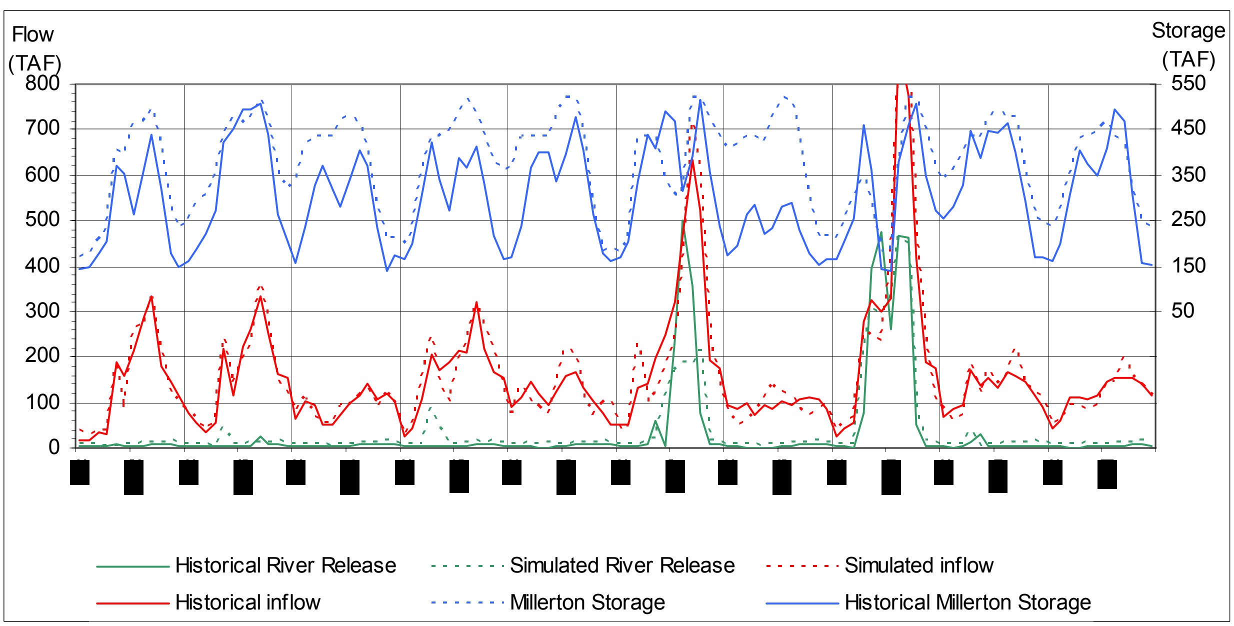

FIGURE A.6-2. SIMULATION OF MILLERTON RESEVOIR 1962-1971

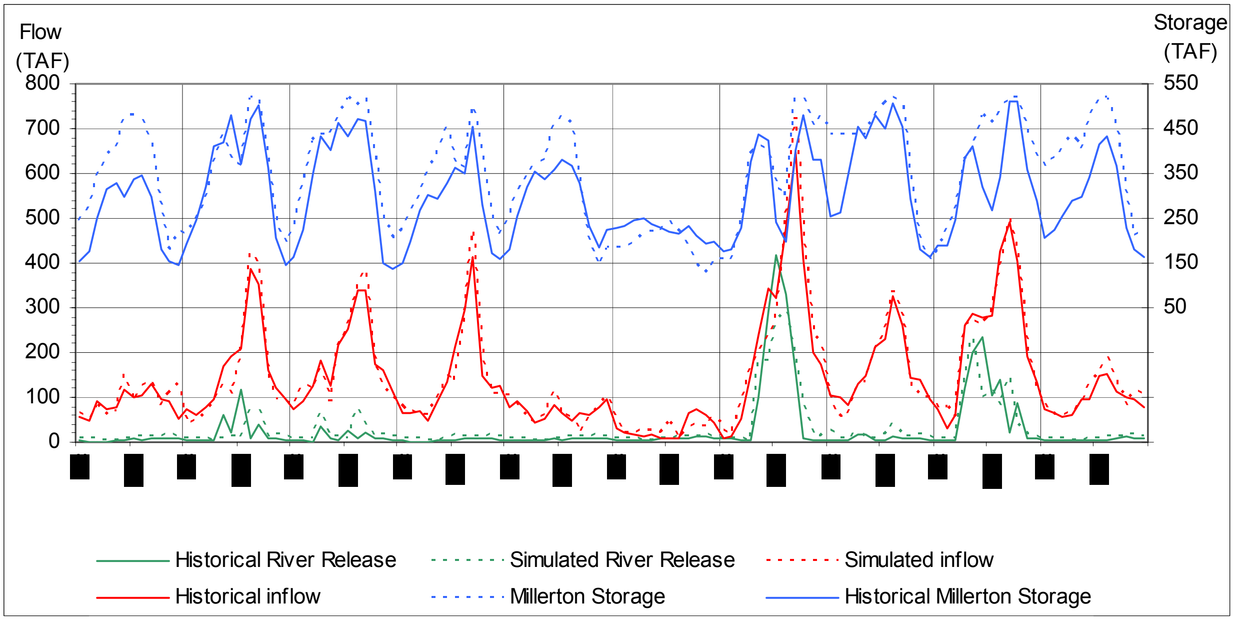

FIGURE A.6-3. SIMULATION OF MILLERTON RESEVOIR 1972-1981

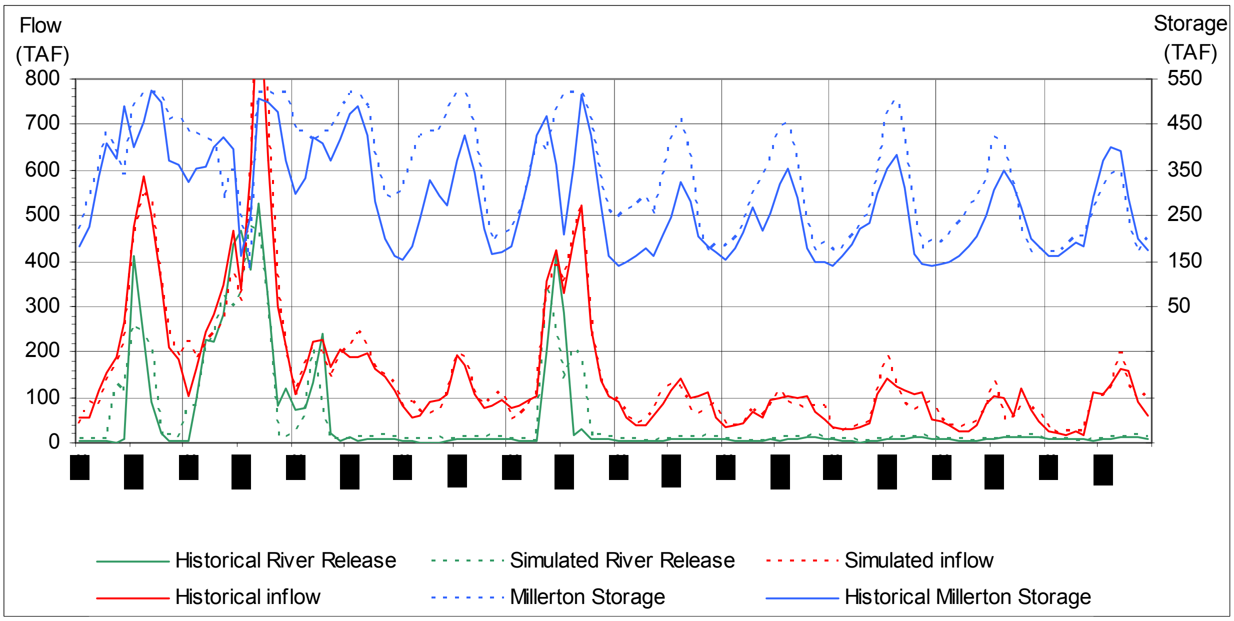

FIGURE A.6-4. SIMULATION OF MILLERTON RESEVOIR 1982-1991

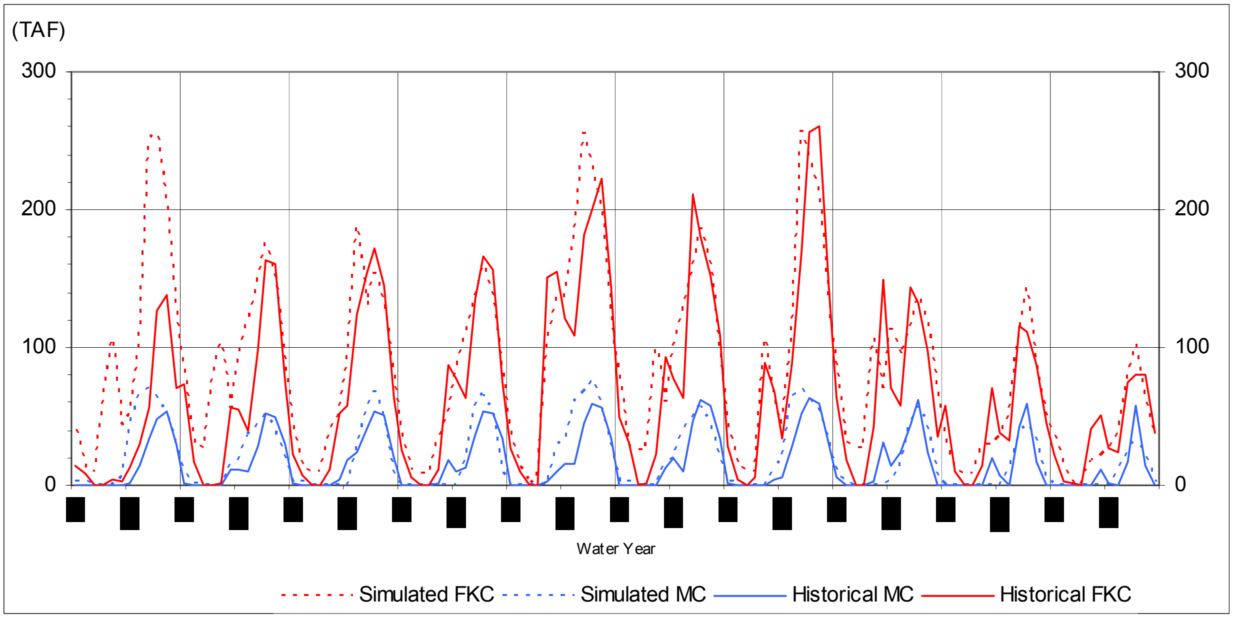

FIGURE A.6-5. SIMULATION OF FRIANT-KERN AND MADERA CANALS 1952-1961

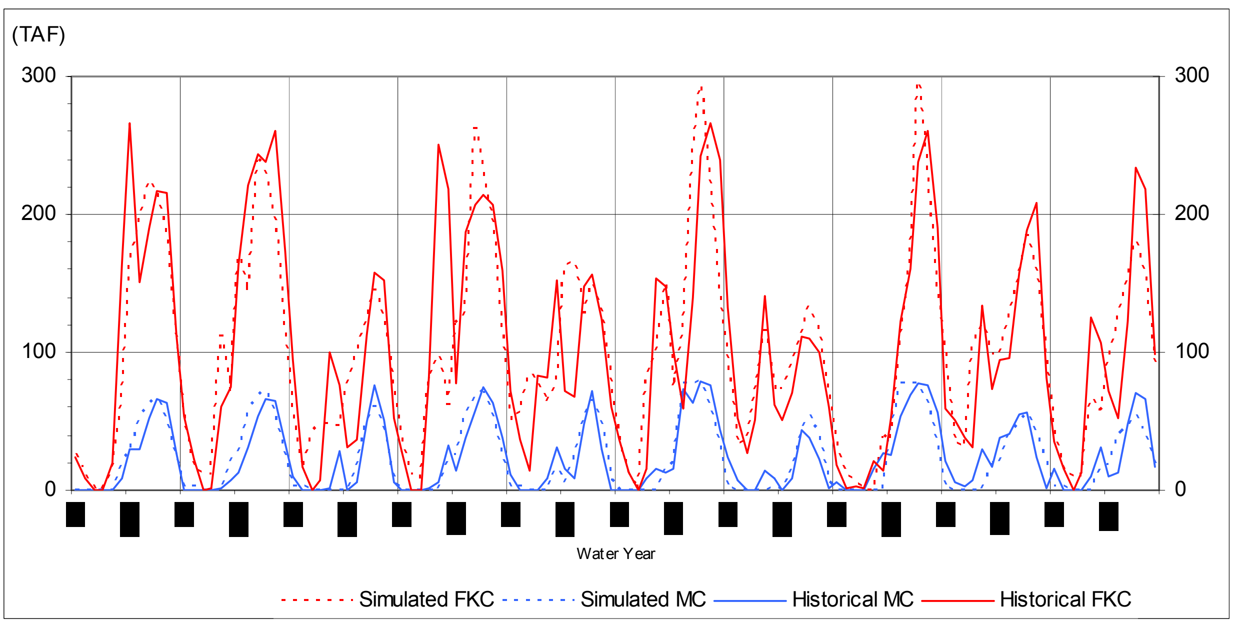

FIGURE A.6-6. SIMULATION OF FRIANT-KERN AND MADERA CANALS 1962-1971

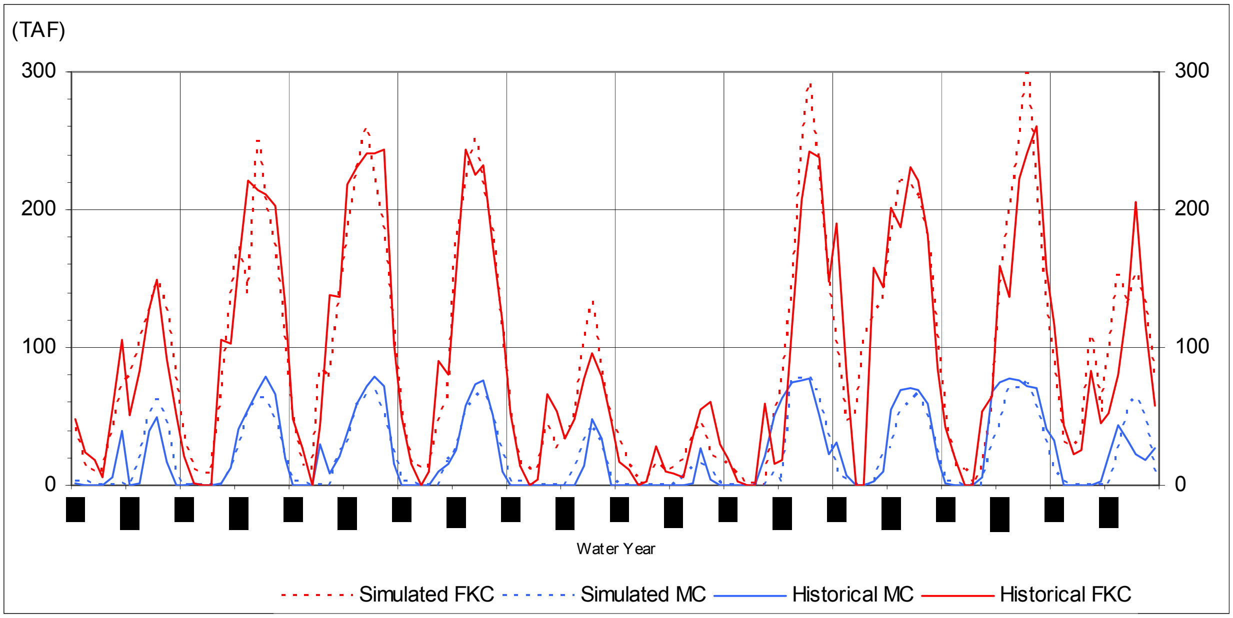

FIGURE A.6-7. SIMULATION OF FRIANT-KERN AND MADERA CANALS 1972-1981

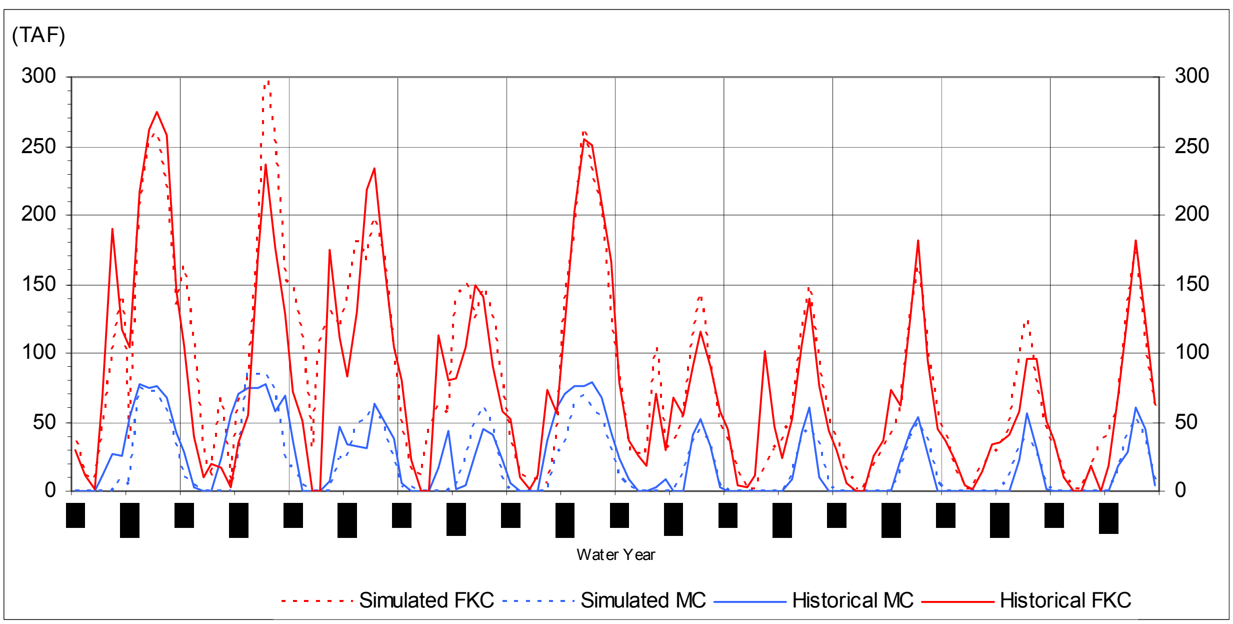

FIGURE A.6-8. SIMULATION OF FRIANT-KERN AND MADERA CANALS 1982-1991

TABLE A.6-1
MILLERTON RESERVOIR END OF MONTH STORAGE (1,000 ACRE-FEET)

M

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1922	338	376	436	436	436	386	231	289	521	513	363	299
1923	272	298	373	436	421	450	520	520	500	419	317	300
1924	323	362	385	408	405	455	488	474	347	219	161	174
1925	164	181	212	246	316	335	422	479	459	352	242	224
1926	247	281	312	339	372	411	519	521	461	296	190	195
1927	201	256	314	367	436	478	499	520	521	440	312	273
1928	292	381	429	436	436	478	520	519	451	289	201	202
1929	186	195	213	233	233	257	290	366	317	216	162	190
1930	169	168	186	214	238	269	350	351	334	216	161	190
1931	175	182	201	227	240	257	304	314	241	166	133	159
1932	156	154	218	291	436	468	457	414	490	434	287	236
1933	244	279	301	335	336	372	400	313	362	300	218	225
1934	225	237	280	332	357	443	520	490	362	226	172	179
1935	174	193	235	310	382	376	414	456	511	379	240	201
1936	216	259	284	331	436	462	509	521	506	369	233	190
1937	194	228	270	313	436	479	459	519	521	383	214	154
1938	166	205	399	436	319	361	368	334	521	521	444	378
1939	365	387	405	436	396	478	521	520	393	218	144	166
1940	172	177	197	333	436	478	509	521	519	374	242	211
1941	219	254	350	436	436	479	454	505	521	516	403	348
1942	338	370	436	436	436	413	439	459	521	494	351	289
1943	272	324	361	412	436	479	521	521	496	358	221	178
1944	181	218	245	283	305	354	369	420	406	313	225	225
1945	238	301	364	415	436	479	463	459	484	415	287	246
1946	289	381	436	436	436	478	520	521	508	372	253	250
1947	281	367	436	436	436	478	519	520	431	284	200	211
1948	212	228	246	268	266	246	289	337	386	297	202	208
1949	227	249	274	301	311	324	400	477	473	310	210	215
1950	230	253	279	329	395	410	514	520	494	344	223	220
1951	240	377	381	436	436	473	519	485	449	344	258	243
1952	245	264	336	436	419	340	358	475	521	515	436	380
1953	350	361	394	436	409	438	463	394	355	319	245	234
1954	231	246	269	307	343	391	497	520	480	337	221	202
1955	215	245	285	334	363	387	390	391	428	304	220	224
1956	223	238	348	348	436	479	521	517	521	499	405	359
1957	357	385	399	429	415	432	417	391	458	362	262	240
1958	253	279	329	377	368	289	339	460	521	515	409	356
1959	327	338	345	384	388	478	520	498	416	273	176	210
1960	215	222	233	253	284	320	413	440	368	234	177	186
1961	169	185	225	253	273	290	350	345	277	177	154	171
1962	169	179	209	240	404	398	463	471	501	412	276	235
1963	251	288	308	353	436	477	466	479	520	469	351	319
1964	336	418	436	436	436	474	481	466	410	275	207	213
1965	198	229	362	436	436	448	483	520	488	432	383	356
1966	366	436	436	436	436	478	521	520	437	275	182	192
1967	182	209	434	436	436	337	305	311	521	521	472	431
1968	409	419	436	436	423	478	520	516	429	295	210	217
1969	212	249	301	348	287	183	186	369	521	521	446	363
1970	341	360	395	436	429	479	493	476	475	352	262	243
1971	239	273	352	428	436	446	467	435	417	320	245	237
1972	247	276	339	387	411	478	480	472	417	267	182	218
1973	215	245	293	373	436	386	365	519	521	382	241	198
1974	222	327	426	436	436	474	518	504	521	384	252	206
1975	222	266	307	353	398	456	371	362	503	387	244	212
1976	254	311	344	371	379	461	479	461	327	192	145	183
1977	183	185	197	217	221	224	246	219	185	144	130	157
1978	157	157	235	395	409	404	323	298	521	521	457	482
1979	436	436	436	436	436	479	506	521	507	338	198	160
1980	178	229	267	380	405	479	462	493	521	521	447	388
1981	367	386	406	436	407	475	520	519	453	296	213	223
1982	219	287	354	436	386	341	489	521	521	515	460	468
1983	436	432	418	412	284	353	239	130	521	521	516	520
1984	436	436	407	436	436	478	520	519	491	377	295	288
1985	309	374	424	436	436	478	520	519	434	284	193	213
1986	217	253	324	416	390	479	521	521	521	458	317	259
1987	247	265	273	293	252	335	418	463	370	227	168	187
1988	182	199	232	297	332	373	445	452	366	233	176	190
1989	172	177	204	235	260	330	473	506	410	250	180	195
1990	192	207	233	267	288	330	423	405	317	215	170	179
1991	168	167	183	202	205	261	311	342	349	230	168	200
1992	187	202	232	266	319	362	470	509	375	239	178	187
1993	174	184	223	412	431	435	416	521	521	515	391	337
1994	324	340	355	381	347	425	462	472	407	270	188	200
Average	247	278	321	363	377	406	437	451	447	350	259	247
Max	436	436	436	436	436	479	521	521	521	521	516	520
Min	156	154	183	202	205	183	186	130	185	144	130	154

TABLE A.6-2
FRIANT-KERN AND MADERA CANAL DIVERSIONS (1,000 ACRE-FEET)

Fr

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	5	4	14	75	69	150	223	248	332	293	257	151	1821
1923	92	33	27	28	105	86	138	252	217	256	210	116	1560
1924	47	17	11	11	42	23	28	52	115	148	92	42	628
1925	29	12	1	1	14	54	89	137	204	242	197	91	1073
1926	39	13	10	10	36	53	112	208	170	204	164	77	1096
1927	34	11	8	8	79	91	198	262	315	269	220	122	1617
1928	49	17	11	44	59	104	110	192	187	224	180	84	1263
1929	36	12	9	9	33	30	37	67	152	195	121	54	754
1930	38	15	1	1	18	30	36	66	151	193	120	54	724
1931	37	15	1	1	18	16	19	35	75	96	61	28	403
1932	20	9	1	1	20	88	209	273	305	295	242	133	1596
1933	54	18	12	12	48	52	85	131	194	229	188	87	1110
1934	38	12	9	9	35	27	47	58	131	169	105	48	688
1935	33	13	1	1	16	81	200	266	306	270	221	122	1532
1936	50	17	11	11	32	152	134	279	251	277	227	125	1564
1937	51	18	12	12	0	63	118	204	331	291	238	131	1468
1938	53	18	12	75	114	4	98	187	315	381	275	157	1689
1939	93	33	30	40	117	63	154	92	176	226	139	63	1225
1940	43	17	1	0	4	130	191	254	262	237	194	107	1441
1941	44	16	10	43	34	151	167	172	324	333	252	140	1685
1942	81	30	42	99	122	169	224	233	321	306	255	141	2023
1943	82	32	26	19	139	25	125	286	259	289	236	130	1648
1944	53	18	12	12	47	54	89	136	202	241	195	90	1149
1945	39	12	9	9	30	96	214	286	314	303	248	136	1696
1946	55	19	81	86	63	83	183	249	203	245	195	91	1554
1947	39	12	33	63	74	78	82	184	169	203	164	77	1178
1948	34	11	8	8	31	46	76	115	170	205	164	77	944
1949	34	11	8	8	31	51	83	127	189	227	182	85	1035
1950	37	12	9	9	34	56	92	186	199	237	192	89	1149
1951	38	5	83	83	102	74	113	161	197	233	191	106	1385
1952	43	15	10	55	107	50	93	167	321	320	255	149	1585
1953	91	31	27	72	104	72	110	158	193	228	187	103	1376
1954	43	15	10	10	37	54	89	216	186	224	180	84	1147
1955	36	12	9	9	33	52	85	130	193	228	187	87	1061
1956	37	12	0	5	103	165	170	242	325	308	256	142	1764
1957	82	32	26	26	101	77	118	169	207	245	201	111	1395
1958	45	16	11	11	107	70	64	173	329	299	262	153	1540
1959	94	32	27	27	107	70	117	110	163	196	157	74	1175
1960	33	11	8	8	30	29	36	65	147	188	117	53	723
1961	37	15	1	1	18	22	26	48	106	136	85	39	531
1962	27	11	1	1	13	86	188	248	288	283	232	128	1506
1963	52	18	12	12	112	93	198	201	307	301	246	135	1687
1964	55	19	42	48	49	47	77	118	174	208	168	79	1082
1965	34	11	8	82	98	85	146	186	330	300	245	134	1660
1966	54	60	86	78	64	94	169	191	180	218	174	81	1451
1967	35	12	0	82	99	166	93	193	321	373	274	166	1815
1968	93	33	36	69	117	74	73	108	157	189	152	72	1170
1969	32	11	8	0	0	40	81	186	246	379	283	171	1436
1970	95	34	31	104	120	118	118	168	205	243	199	110	1546
1971	45	16	10	10	67	74	114	164	200	237	194	107	1239
1972	44	16	10	10	39	75	79	121	179	213	173	81	1039
1973	35	12	9	9	60	147	200	192	314	266	218	120	1582
1974	49	17	11	85	78	163	208	285	327	287	235	129	1875
1975	52	18	12	12	46	84	204	274	315	281	230	127	1657
1976	51	18	12	12	46	27	33	61	137	175	109	49	730
1977	34	14	1	1	17	11	13	24	49	62	32	19	276
1978	14	7	1	1	0	62	76	216	320	372	285	175	1530
1979	110	50	51	105	124	158	204	275	279	275	226	124	1981
1980	50	17	12	0	13	87	186	269	319	380	264	157	1755
1981	96	33	28	34	110	53	96	177	185	220	179	84	1294
1982	36	12	9	43	100	153	41	278	325	333	274	162	1766
1983	173	107	25	10	68	5	90	164	257	393	316	174	1782
1984	163	112	32	107	132	142	162	230	220	260	213	118	1891
1985	48	17	11	44	61	56	144	173	176	210	170	80	1189
1986	35	11	8	8	6	63	169	249	332	288	255	149	1573
1987	91	33	27	27	104	29	36	65	147	189	117	53	918
1988	37	15	1	1	18	30	37	67	152	195	120	54	726
1989	38	15	1	1	18	33	40	73	166	213	131	59	788
1990	41	16	1	1	20	26	31	57	128	164	102	46	632
1991	32	13	1	1	16	35	42	77	176	226	139	63	821
1992	43	17	1	1	21	30	36	66	149	191	119	54	728
1993	37	15	1	1	85	164	169	248	330	308	257	142	1757
1994	83	32	26	26	101	42	70	106	155	187	150	71	1047
Average	53	21	16	28	59	74	112	170	225	248	193	102	1300
Max	173	112	86	107	139	169	224	286	332	393	316	175	2023
Min	5	4	0	0	0	4	13	24	49	62	32	19	276

TABLE A.6-3
FRIANT RELEASE TO SAN JOAQUIN RIVER (1,000 ACRE-FEET)

Fr

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1922	10	7	7	15	45	7	112	98	92	14	16	13	437
1923	10	7	7	5	5	7	9	11	13	14	16	13	117
1924	10	7	7	5	5	7	9	11	13	14	16	13	117
1925	10	7	7	5	5	7	9	11	13	14	16	13	117
1926	10	7	7	5	5	7	9	29	13	14	16	13	135
1927	10	7	7	5	9	7	9	11	57	14	16	13	165
1928	10	7	7	7	12	7	9	11	13	14	16	13	126
1929	10	7	7	5	5	7	9	11	13	14	16	13	117
1930	10	7	7	5	5	7	9	11	13	14	16	13	117
1931	10	7	7	5	5	7	9	11	13	14	16	13	117
1932	10	7	7	5	6	7	9	11	13	14	16	13	118
1933	10	7	7	5	5	7	9	11	13	14	16	13	117
1934	10	7	7	5	5	7	9	11	13	14	16	13	117
1935	10	7	7	5	5	7	12	11	19	14	16	13	126
1936	10	7	7	5	67	7	83	57	13	14	16	13	299
1937	10	7	7	5	112	124	169	174	63	14	16	13	715
1938	10	7	7	9	227	281	315	439	358	47	16	13	1729
1939	10	7	7	5	5	7	20	11	13	14	16	13	128
1940	10	7	7	5	26	7	9	65	13	14	16	13	191
1941	10	7	7	7	164	17	103	187	213	14	16	13	760
1942	10	7	8	49	13	7	15	11	103	14	16	13	266
1943	10	7	7	83	15	186	111	54	13	14	16	13	529
1944	10	7	7	5	5	7	9	11	13	14	16	13	117
1945	10	7	7	5	191	7	16	11	13	14	16	13	310
1946	10	7	12	21	12	7	9	52	13	14	16	13	187
1947	10	7	8	9	8	7	9	11	13	14	16	13	125
1948	10	7	7	5	5	7	9	11	13	14	16	13	117
1949	10	7	7	5	5	7	9	11	13	14	16	13	117
1950	10	7	7	5	5	7	9	11	13	14	16	13	117
1951	10	48	225	78	32	7	9	11	13	14	16	13	477
1952	10	7	7	8	23	179	175	284	221	14	16	13	957
1953	10	7	7	8	5	7	9	11	13	14	16	13	120
1954	10	7	7	5	5	7	9	11	13	14	16	13	117
1955	10	7	7	5	5	7	9	11	13	14	16	13	117
1956	10	7	208	278	32	17	38	85	172	14	16	13	891
1957	10	7	7	5	5	7	9	11	13	14	16	13	117
1958	10	7	7	5	26	179	168	244	168	14	16	13	857
1959	10	7	7	5	5	7	9	11	13	14	16	13	117
1960	10	7	7	5	5	7	9	11	13	14	16	13	117
1961	10	7	7	5	5	7	9	11	13	14	16	13	117
1962	10	7	7	5	5	7	9	11	13	14	16	13	117
1963	10	7	7	5	47	7	9	11	13	14	16	13	159
1964	10	7	9	7	5	7	9	11	13	14	16	13	121
1965	10	7	7	91	42	7	9	11	17	14	16	13	245
1966	10	10	14	9	12	7	10	11	13	14	16	13	140
1967	10	7	7	16	21	114	170	189	186	217	16	13	966
1968	10	7	7	7	5	7	9	11	13	14	16	13	120
1969	10	7	7	210	306	300	325	464	447	81	16	13	2188
1970	10	7	7	41	5	7	9	11	13	14	16	13	153
1971	10	7	7	5	12	7	9	11	13	14	16	13	124
1972	10	7	7	5	5	7	9	11	13	14	16	13	117
1973	10	7	7	5	7	12	9	75	72	14	16	13	248
1974	10	7	7	69	13	14	9	80	39	14	16	13	292
1975	10	7	7	5	5	7	15	11	13	14	16	13	124
1976	10	7	7	5	5	7	9	11	13	14	16	13	117
1977	10	7	7	5	5	7	9	11	13	14	16	13	117
1978	10	7	7	5	183	183	267	298	178	87	16	13	1253
1979	24	8	8	25	10	7	17	44	13	14	16	13	198
1980	10	7	7	148	235	98	118	82	148	40	16	13	923
1981	10	7	7	5	5	7	9	11	13	14	16	13	117
1982	10	7	7	7	126	110	262	234	201	14	16	13	1008
1983	82	81	210	236	324	301	335	474	469	288	16	13	2829
1984	25	63	205	63	9	7	9	11	13	14	16	13	447
1985	10	7	7	7	12	7	9	11	13	14	16	13	126
1986	10	7	7	5	345	240	136	211	182	14	16	13	1186
1987	10	7	7	5	5	7	9	11	13	14	16	13	117
1988	10	7	7	5	5	7	9	11	13	14	16	13	117
1989	10	7	7	5	5	7	9	11	13	14	16	13	117
1990	10	7	7	5	5	7	9	11	13	14	16	13	117
1991	10	7	7	5	5	7	9	11	13	14	16	13	117
1992	10	7	7	5	5	7	9	11	13	14	16	13	117
1993	10	7	7	5	27	15	96	116	183	14	16	13	510
1994	10	7	7	5	5	7	9	11	13	14	16	13	117
Average	11	10	18	24	40	38	48	63	58	24	16	13	363
Max	82	81	225	278	345	301	335	474	469	288	16	13	2829
Min	10	7	7	5	5	7	9	11	13	14	16	13	117

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